SCIENTIFIC AMERICAN
No. SUPPLEMENT, 79

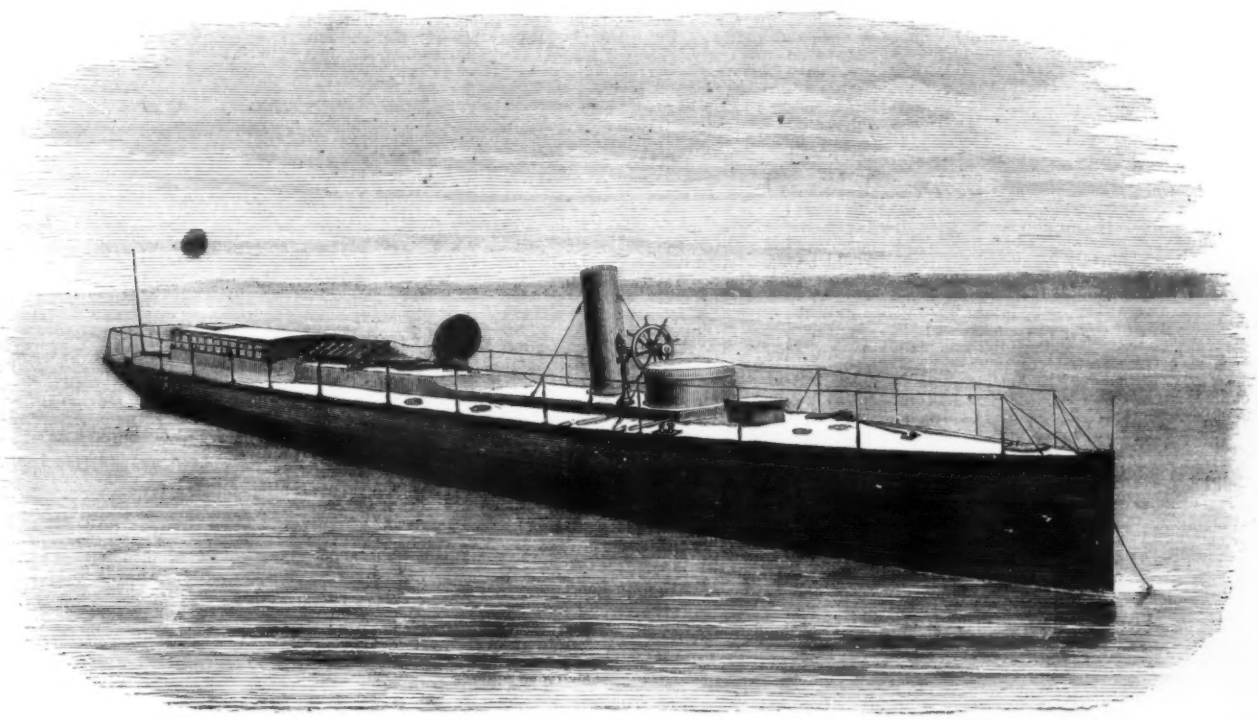
Scientific American Supplement, Vol. IV, No. 79. } NEW YORK, JULY 7, 1877. { Scientific American Supplement, $5 a year.
Scientific American, established 1845. } { Scientific American and Supplement, $7 a year.

THE THORNYCROFT TORPEDO VESSELS.*

By Mr. Donaldson.

Speaking generally, naval warfare heretofore has been conducted on the surface of the water, and a fighting ship has usually been constructed so as to carry her offensive and defensive equipment about and above her water line; her guns and the bulk of her armor-plating being always above that line, and the remainder of her armor-plating only extending below it sufficiently far to protect the vessel from shot while rolling. The thickness and strength of the bottom have been usually determined by structural considerations, and in modern ironclads it has been kept as light as possible in order to secure the buoyancy necessary for carrying the heavy guns and the heavier plating of these huge vessels; the consequence is that the bottom of an ironclad is her most vulnerable part, and a vessel costing half a million of money, and carrying, say, 500 men, may be sent to the bottom at any moment by means of ramming or the successful explosion of a torpedo. It may be urged that ramming is not always successful, and doubtless, the ram—being of necessity a heavy and ungainly vessel, not easily diverted from its path—may be eluded by skill and dexterity on the part of the officers and crew of the intended victim. From a well planned torpedo attack, however, in sufficient force, I believe there is no escape, and it is of vessels specially constructed for this purpose that I propose to address you this afternoon. I think I am right in stating that the first attempt to use torpedo boats systematically was made during the American War, and as two vessels at least—the United States steamer Housatonic and the Confederate ram Albemarle — were actually sunk, and several others severely damaged by means of these weapons—besides the apprehension excited among all the vessels engaged—the attempt may be considered as having been decidedly successful. The torpedo boats used on these occasions were either submarine boats, specially designed and constructed for the purpose, or ordinary steam launches fitted with outrigger torpedoes. Neither of these types of boat is well suited for the work, as, in the first case, independently of the difficulty of steering a boat under water, it would be almost certain to be destroyed when the torpedo exploded, and so sacrifice the crew engaged in the attack, as happened in the case of the sinking of the Housatonic; and, in the second case, the noise from the funnel, and the want of speed in ordinary steam launches, would effectually, except when the attack was made on a dark night, betray their position, and allow them to be made targets of long before they came any way near their enemy. Von Scheliha, in reviewing the experience gained during the American War in the use of torpedo boats, considers that submarine boats acting independently are quite unsuited for torpedo warfare, and that a swift jolly-boat, rowed with muffled oars, and provided with a self-acting contact torpedo, fastened to the socket of a movable torpedo spar 12 ft. long, was preferable to any submarine boat. He further states that the general conclusions arrived at by American engineers were: "That a torpedo boat should have a speed of at least 11 knots, as the greater the speed the less is the danger of being discovered, or struck by the enemy's missiles; that the engine must work without noise, and no smoke should be visible; that the boat must obey the rudder, and that the crew should be protected against musketry and the fire of light artillery." The majority of these requirements could be satisfied without much difficulty; but the problem as to speed remained—as far as small boats were concerned—unsolved till 1871, when Mr. Thornycroft brought out the far-famed Miranda, a vessel under 50 ft. in length, which, when experimented on by Mr. Bramwell in the spring of 1872, attained the astonishing speed of 18·65 statute miles, or nearly 16¼ knots per hour. These remarkable results did not remain long unnoticed by torpedoists, as about this time the Whitehead torpedo was being introduced, and the question of how best to use torpedoes in offensive warfare was beginning to receive that attention which I have no doubt will be well justified in the next great naval war. The first Government to recognize the great advance made by Mr. Thornycroft in the speed of small boats was the Norwegian, which, in 1873, gave my firm an order for our first torpedo boat. This boat was 57 ft. in length by 7 ft. 6 in. beam, drew 3 ft. of water, and the stipulated speed was 16 English statute miles, or nearly 14 knots per hour, which speed was not to be ascertained by a mere measured mile trial, but was to be 16 miles through the water in a run of one hour's duration. The hull of the vessel was constructed entirely of steel plates and angle bars, and was divided into six water-tight compartments. The compartments in the stem and stern were for stores; two others were fitted with seats for the crew, and were provided with movable steel covers, so that on going into action, or during rough weather, they might be completely covered. The two remaining compartments are for the steersman and the machinery respectively, and were covered completely by steel plating $\frac{3}{16}$ in. in thickness—a thickness which has been found sufficient to withstand Snider or Martini-Henry bullets, fired from a distance of twenty paces, as illustrated by the specimens on the table. One compartment was furnished with a hood, having slits ¼ in. wide all round, through which the steersman could see with sufficient distinctness to direct his course easily. Motion was communicated from the wheel to the tiller by means of steel wire ropes, which it was originally intended should be encased in wrought iron tubes. The possibility, however, of these tubes being bent by a shot, and so jamming the wire ropes, led to this arrangement being abandoned, and the ropes were simply run through eyes at intervals along the side. The engines were compound, of the usual inverted double cylinder direct-acting type, capable of developing about ninety indicated horse-power, and were fitted with a surface condenser, so that the vessel could run in salt water without danger of injuring her boiler. A small tank contained a supply of fresh water, to make good deficiencies arising from leakage, and from steam escaping at the safety valves, etc. The circulating, air, and feed pumps were driven by a separate engine, as we feared at that time that it would be impossible to run them at the same speed as the main engines. The boiler was of the locomotive type, the shell being made of Bessemer steel; the fire-box, and its stays of copper, and the tubes of solid drawn brass. The armament was not supplied by us, but I have reason to believe that it consisted of a cylindro-conical shaped torpedo towed from the top of the funnel, round which a ring was fitted with two pulleys for the towing ropes; the strain being taken off by means of two stays attached forward. The length of this torpedo was 13 ft., and the diameter 9 in., and with a speed of 11 knots, it has diverged to about 40° from the direction of the boat's motion when running in smooth water. The torpedo is worked by means of a small winch and brake fixed on the after part of the engine-room skylight; davits are provided for dropping the torpedo overboard.

On the official trial, which took place on the Thames on the 17th October, 1873, the number of revolutions done in the hour was found to be 27,177, and the number required to do a mile in still water was 1,578. The distance run in the hour was, then, $\frac{27,177}{1,578} = 17·22$, or very nearly 17¼ miles. The steam pressure during the trial averaged 85 lbs. per square inch, and the vacuum 25½ in. Boats of the same size, and similar in all particulars—excepting the engines which we improved by driving the air-pump, feed-pump, and circulating pumps off the main engines, and abolishing the auxiliary engine, which performed these duties in the case of the Norwegian boat—were made for the Swedish and Danish Governments. The result was an increase of speed to 17·27 miles, in the case of the Swedish boat, and to 18·06 miles, or 15⅝ knots, in the case of the Danish boat. I have no information regarding the armament of the Swedish boat, but the Danish boat was armed with two spindle-shaped torpedoes 12 ft. long and 11½ in. diameter, somewhat like the Whitehead torpedo. They were placed on the deck longitudinally near the funnel, so as to facilitate launching, and were arranged to be towed from an upright pole 8 ft. high, placed about 6 ft. from the stem. A small winch was fixed on either side aft, to pay out the towing line, and to bring back the torpedo. By these arrangements the torpedo could be projected at a large angle from the direction of the boat's motion, and at considerable velocity. The speed of the boat when towing one of these torpedoes is about 10 knots. With regard to the strength of boats of this type, I may mention that when the Norwegian boat was fixed on board the steamer for conveyance to Norway, that vessel when going out of dock came into collision with a telegraph-cable-laying steamer, the bow of which penetrated the side of the torpedo vessel, and pulled her off the chocks on which she rested, causing her to fall a distance of from 15 in. to 18 in., and bending her bottom slightly, but otherwise doing so little damage that she started immediately on her arrival at Stockholm on a voyage of 150 nautical miles to her destination in Norway. With regard to their sea-worthiness, I think I cannot do better than read the following extract from a letter addressed to me by Captain Koren, of the Norwegian navy, in which he describes this very voyage: "In reply to your letter of the 14th, I have the pleasure to give you the following account of my trip in November last, from Götheburg to Horten—a distance of about 150 nautical miles—in the launch built by your honored firm for our torpedo service. The season being far advanced, I was anxious to take the boat to Norway as soon as possible, so having patched up the hole in her larboard quarter, and made a short trial trip, to see if the engine was in good working order, we started from Götheburg at two in the afternoon on the 21st of



THE TORPEDO BOAT, LIGHTNING.

* Read before the United Service Institution.

November. It had been blowing stiffly the whole day from southwest, and my friends asked me not to start that day, as there would be a heavy sea rolling into the fiord, which I had to cross to get to the new canal and inshore passage to Marstrand, where I intended to stop for the night. Time pressed, however, and I started. I had engaged a Swedish pilot for the whole voyage on the testimony of his having traded on this coast for twenty-five years, and not doubting that he knew every creek and passage. When we got out in the above-mentioned fiord, it was blowing a stiff double-reefed-topsail breeze, with a corresponding but confused sea, but still we had some shelter from the outlying rocks. I ordered the pilot to steer for the opening of the canal on the other side, a route which would let us have the sea about four points on our port quarter; but that fellow coolly told me that he never went that way; he only knew the circuitous outer route, which would take us out into the open sea to round the island on which Marstrand is built. I did not know what to do at the first; it was getting dark and the wind was freshening, and the boat certainly did not look like a sea-going craft; but we had come thus far, and I thought it best to push on. We had about fifteen minutes to run with the sea on the beam, and when we lost shelter from the rocks, her movements were quite extraordinary, alarmingly quick, and great. However, she shipped no water, and, having observed her for some little time, I knew there was no danger, and it was with a sort of pleasure I heard that stupid fellow of a pilot ask, 'If I thought the boat would capsize?' When we had rounded the last island, and began running before the wind, the boat went quite steady, and we got safely into the harbor. Two hours after we came in it was blowing a most violent gale. The next day we had to pass outside the rocks for a distance of 20 miles; the wind had gone down, but there was a heavy swell. We had a pressure in the boiler of about 50 lbs. only, and the only inconvenience we experienced was the constant priming when the boat was rolling, and the impossibility of using the injector, so we were obliged to keep the donkey going all the time. We got to Horton in good time, and all safe, and, after my opinion, the boat is much more sea-worthy than one could possibly think, judging from a hasty glance only." In a subsequent letter Captain Koren says: "We ran on a flat rock with your launch last year, and with tolerable good speed, too. In backing, the two-bladed screw knocked against the rock and got a very curious new twist. The blades did not break, and the boat came off without any sort of injury, as happily the rock was quite smooth, but the test was rather severe."

The next size of torpedo vessel is that supplied to the Austrian and French Governments. The dimensions are: Length, 67 ft.; beam, 8 ft. 6 in.; draught of water, 4 ft. 3 in. The guaranteed speed in the case of the Austrian boat was 15 knots in a run of one hour's duration, and in the case of the French boats 18 knots in a run of two hours' duration. These boats were built of thicker plating than the 57 ft. type, and the armor was extended down to the water-line on each side. They were divided into six water-tight compartments, and they differed from the Scandinavian boats in having the spaces forward and aft of the machinery permanently decked, instead of being covered with movable steel covers only. The machinery was somewhat similar to that in the Scandinavian boats, excepting that the engines were capable of developing 200 indicated horse-power, and that the air was supplied to the furnace by being forced into an air-tight stoke-hole instead of being forced directly under the fire-grate. The armament of these vessels consisted of two torpedoes attached to the end of wooden poles, 4½ in. diameter and about 43 ft. long, connected to the battery by insulated wires, and arranged to be fired either by coming in contact with the enemy's vessel or at any distance from it, at the will of the operator. The torpedoes themselves were simply copper cases, of sufficient size, in the case of the Austrian boat, to contain 11,000 cubic centimeters of explosive, and in the case of the French boats to contain 25 kilogrammes of dynamite. At one end is the socket for the pole, and at the other the contact arrangement, which consists of a metallic plate capable of being pressed against the ends of the studs to which the wires are attached. This plate and its connections are covered by an india rubber cap, so as to render the cases water-tight. In the middle of the case is the aperture for charging the torpedo. This is a hole 3½ in. in diameter, into which, when the torpedo is filled, is screwed a cap. The wires are introduced by an aperture fitted with a screw gland, so as to prevent the ingress of water. The battery is a modification of Smee's well-known single acid battery, and consists of six cells, fitted with platinized silver and zinc plates, which, in order to prevent unnecessary oxidation, may be lifted and kept clear of the acid. The fuse—several specimens of which are on the table—consists of two strong copper wires, kept apart by means of a non-conducting composition, and connected by a very fine platinum wire, imbedded in fulminate of mercury, which is protected by a tinfoil casing. These fuses are used with a detonator—a long copper cap half filled with fulminate of mercury. The connecting wires are arranged in the neat and effective way patented by Captain Evoy (see engraving on another page), of the London Ordnance Works, by means of which, with only three wires, the torpedo may be made to explode either on contact with the enemy's vessel or by means of a firing key, at the will of the operator. The arrangement for working the torpedo poles consists of two tubes riveted together at right angles so as to form something like the letter T. The torpedo pole is put through the horizontal tube, which is free to move round the center of the vertical tube, and the vertical tube is free to move through a quarter circle at right angles to the center line of the vessel. In attacking in front, the vertical tube is laid over till it is parallel to the water surface, and the horizontal tube is allowed to incline sufficiently far to allow of the end of the pole, when run out, to be depressed from 8 ft. to 10 ft. below the water line. It is held in this position by a pair of blocks attached to the top of the short mast A. In attacking on the broadside the vertical tube is laid over till it assumes a position such as to allow of the pole when swung round to touch an enemy's vessel at about 8 ft. or 10 ft. below the water line. The speed trials of the Austrian boat took place on the 11th September, 1875, when she did 24,700 revolutions on her hour's run on the Thames, and the number of revolutions required to do a knot in still water was found to be 1,357. This gives the distance run in the hour as 18·203 knots, or 3·202 knots over our contract speed. The steam pressure averaged 105 lbs. per square inch, and the vacuum 25½ in. during the run. In the case of the French boats, the total number of revolutions done in two hours' run in the roadstead off Cherbourg was 49,818, and the number required to do a knot in still water was found to be 1,382, so that the distance run in the two hours was 36·05 knots, or just over our contract speed. During the two hours the average steam pressure was 108 lbs. per square inch, and the vacuum 25 in. The Austrian boat was sent to her destination on board a steamer, but the French boats, under the command of an experienced captain, steamed by themselves from Chiswick to Cherbourg, not crossing at the nearest points and running along the shore, but going boldly from Dover direct to Cherbourg. Shortly after the arrival of the French boats in Cherbourg they were altered so as to attack in front only, as the French authorities found that these small vessels were better adapted for resisting the effects of an explosion at the bow than at any other part.

The arrangement adopted consisted of a steel pole about 40 ft. in length, having one end about 6 in. diameter, and solid, and the other about 1½ in. diameter, and hollow; this pole was mounted at its solid end on small pulleys which ran upon two ropes stretched fore and aft of the vessel; the other end, to which the torpedo was attached, was led over a pulley fixed on the bow. Ropes passing over pulleys to a windlass in the after compartment were attached to the inboard end, and by turning the windlass the pole was drawn backwards or forwards as required. It will be observed that as the pole is drawn forward, the inboard end being constrained to move in a line parallel to the deck, the outer end is depressed in the water, and is so adjusted that when the pole is run out to its full extremity, the torpedo is depressed to about 8½ ft. below the water level. The arrangements for firing were, I believe, similar to those described as having been fitted to the boats by us; but of this I have no definite information.

In February and March of this year some very remarkable experiments were made at Cherbourg with these boats, which not only showed the terrible effect of an explosion on the vessel operated upon, but also the small effect that the explosion has on the torpedo boat. The last of these experiments was made in the roadstead off Cherbourg on the 3d March, in presence of Vice-Amiral Clorée, Contre-Amiral Jaurez, Contre-Amiral Lafont, and many other officers of the French navy. The vessel attacked was the Bayonnaise, an old wooden frigate of about 2,000 tons displacement, which had been damaged in one of the earlier experiments, and was on this occasion kept afloat by means of empty casks. In order to realize as nearly as possible the actual conditions of warfare, the Bayonnaise was towed by the paddle-steamer Coligny at the rate of about 6 knots per hour. The attacking boat, under the command of M. Lemoine, came up at a speed of about 14 knots, which, on nearing the Bayonnaise, was reduced so as to prevent a collision between the two vessels at the moment of attack. The torpedo charged with 15 kilogrammes of damp guncotton submerged to a depth of 2½ meters, or about 8¼ ft. below the surface of the water, exploded immediately on striking, and the Bayonnaise, with the hole in her bow, shown in the photograph on the table—large enough, I believe, to admit a full-sized omnibus—would at once have gone to the bottom had it not been for the empty casks with which she was filled. At the moment of explosion a slight shock was felt, and immediately afterwards a large wave was upheaved between the Bayonnaise and the torpedo boat, which was driven backward a considerable distance, and completely covered with water, so much so that M. Lemoine and his brave companions for the moment could not say whether they had gone to the bottom or not. This state of doubt was soon dispelled, however, and M. Lemoine steamed slowly off to report himself on board the Coligny. The effect on the torpedo boat in attacking a wooden vessel like the Bayonnaise, half filled with water, with thick wooden planking, and still thicker ribs, is, I believe, greater than it would be in attacking an ironclad, with its bottom of thin iron or steel, and the result showed very clearly that no harm is likely to happen to boats of this class, either in the hulls or the machinery, from the explosion of this formidable weapon.

I may remark that the second Thornycroft boat was not stopped in time, and ran into the Bayonnaise at a speed of about 8 knots, the result being that the bow was doubled up, but so little real harm done, that on the following day she steamed out into the roadstead in rough weather, and returned without shipping more water than could be easily disposed of by her bilge pumps. None of the machinery was displaced, and no joints broken. One important result of the experiments made by the French Government was the finding that only 90 per cent. of the weight of explosive that might be safely fired at the bow could be fired at the stern, and only 35 per cent. on the side. The third size of boat built by us is that we are now supplying to the Dutch and Italian Governments. These vessels are 76 ft. long by 10 ft. beam, and are guaranteed to do a speed of 18 knots. They are similar in design to the French boats, and differ from them in having engines of 250 indicated horse-power, and in having more freeboard forward, so as to make them better sea boats. The Dutch type will be armed with the outrigger torpedo, as supplied to the French Government, and the Italian type with the Whitehead or fish torpedo.

We now come to the "Lightning" type of vessel. This vessel is 84 ft. long over all by 10 ft. 10 in. beam, draws about 5 ft. of water, and is guaranteed to do a speed of 18 knots on her trial. The machinery on board the Lightning is similar in design to that already described, and is capable of indicating 350-horse power. The hull of the Lightning is made of heavier plating than we usually employ, and her lines are fuller, as she is intended for use in a tolerably rough sea if necessary; and in order that she may be able to remain at sea for some time, cabin accommodation on a scale larger than in any of the other boats is provided for the officers and crew. The steering gear is arranged so that the vessel may be steered from the deck or from the conning-tower, and the usual telegraph gear is fitted to communicate from the deck or from the conning-tower to the engine-room. The top of the conning-tower is supported on three screws, so arranged that it may be raised or lowered, and the space for sight adjusted according to the range of vision required or the risk to be run from the enemy's missiles. The Lightning is to be armed with the Whitehead torpedo, which will be discharged from her forward deck by means of a discharging apparatus, the details of which I am not sufficiently familiar with to be able to give a description. The torpedoes will be charged with air by means of one of Mr. Brotherhood's air-compressing pumps. The Lightning has not yet been officially tried, but on her preliminary runs in the Thames she attained a speed on the measured mile of 19·4 knots per hour, a speed which will be somewhat reduced when she has her torpedoes and their gear on board, but which will leave us an ample margin on our guaranteed speed of 18 knots per hour. The next size of boat is the 87 ft. type, of which type we have six in hand at present for the French Government. These vessels are 10 ft. 6 in. beam, and are built of heavier plating than the Lightning, and we have undertaken that they shall maintain a speed of 18 knots in a run of three hours' duration. The propellers, contrary to our usual practice, will be placed in front of the rudders, so as to give increased readiness in steering. In order to prevent oxidation of the hulls as far as possible, we have arranged to galvanize the plates and frames below water line; and a spark-catching apparatus will be fitted to the base of the chimney, so as to prevent the position of the vessel being betrayed to the enemy during the night. The armament of these vessels will be fitted by the French Government, and will, I believe, consist of an outrigger arrangement similar to that now in the boats we formerly supplied to them. They are equally well adapted, however, for the Whitehead torpedo, and they may be fitted with the apparatus for discharging that weapon. They will also be provided with an apparatus for deadening the shock in the event of their coming in contact with an enemy's vessel at too high a rate of speed, as happened to one of our boats during the experiments at Cherbourg.

I have now described the principal features of those boats we have built for torpedo service, and although the results in the matter of speed are high, they are not so high as we have obtained in some of our other boats—as, for instance, in that built by us last year for the Baroness Rothschild, and tried on the Lake of Geneva. This vessel, 90 ft. long by 13 ft. beam, maintained a speed of nearly twenty one knots in a run the whole length of the lake from Geneva to Villeneuve. I may further add, that although this is the fastest boat in a long run we have built as yet, we have designed and are prepared to build boats capable of maintaining a speed of twenty-five knots. These vessels would be larger and more expensive than any I have described, but would, I think, be invaluable in war, either for actual torpedo work or for use as despatch vessels. High speed, although so thoroughly appreciated by foreign torpedoists, has not hitherto received that attention which it merits from our own people. I have reason, however, to believe that this will be remedied as soon as the official trials of the Lightning are concluded, but in the meantime—it may be on the eve of a great war—the fact remains, that we have only one fast steam torpedo launch in her Majesty's navy, while other nations are providing them by the dozen for the defence of their principal ports. In advocating the value of high speed, I have sometimes been told that, although very useful in its way, it is not required for torpedo work, and that an ordinary ship's launch, if directed to move slowly and silently against an enemy's ship, would be quite as efficient as a fast vessel; and as these launches are always required on board ship for other purposes, and are besides much cheaper in first cost, it is better to buy a large number of them than to have a few fast vessels for a special purpose. Doubtless this would be true, if the enemy's vessel were at anchor, and if an inefficient watch were kept on board; but this is a conjuncture which I apprehend would be very rare in modern warfare. I think it may be very safely asserted that numbers are only useful in war when their force can be brought to bear on the enemy; and I am quite certain that any number of ordinary 8-knot steam launches, fitted with outrigger torpedoes, might just as well be away on the China station as any way in the neighborhood of an enemy's ironclad, capable of doing 12 knots, for all the harm they would do her. All the ironclad would have to do would be to keep running at a little slower speed than her Lilliputian foes, and sink them in detail as they came within range. On the other hand, take the case of the same ironclad appearing off one of our ports defended by a fleet of 18-knot torpedo boats. Nothing would require to be done till she came in sufficiently close to use her gun—say three miles at the outside—when, if half a dozen or a dozen 18-knot torpedo vessels were launched against her, they would be alongside in half an hour from the time of their starting, even if the ironclad got away at once, and used her utmost speed in escaping. If the torpedo vessels were armed with the Whitehead torpedo, it would not be necessary for them to go close alongside, and so they would be less easily hit; but the danger of hitting objects running at even a slow speed of 6 knots per hour, or 10 ft. per second, relatively to the ironclad is very slight indeed. Last year at Wimbledon there were 5,000 shots fired at the running deer—a target moving at the rate of 6 ft. per second, and out of these shots, fired from a fixed platform by men who almost make a business of shooting—only one in ten hit the bull's eye at 110 yards; while, if the target was stationary, nine shots out of ten could always be depended upon as being bull's eyes. Add to these difficulties men comparatively unaccustomed to shooting, firing at an uncertain distance from a moving platform, at a target moving twice as fast as the running deer, when the torpedo boat is in chase of an ironclad, or five times as fast if the ironclad is caught napping, and some idea may be formed of the difficulty of hitting these boats. Then if they were hit, no small-arm bullet would penetrate any part of them at even comparatively close ranges on account of the obliquity of the surfaces exposed, while it is calculated that large guns firing shrapnel, if the aiming were accurate and the distance correctly ascertained, could only send one and a half bullets for each round into the area exposed by a vessel as large as the Lightning at 1,000 yards. In considering the question of the safety of the attacking boats, I do not think that sufficient value is given to the demoralizing effect of the stealthy approach of a vessel carrying so tremendous a weapon as a torpedo. The French officers on board the Coligny during the experiments at Cherbourg said they experienced a decidedly uneasy feeling when they saw the two small gray-colored boats gliding silently up, a feeling somewhat akin to that experienced on the approach of a deadly snake. The most valuable experience, however, was acquired during the American War, and Lieutenant Cushing thus describes the dangers he ran from bullets while sinking the Confederate ram Albemarle, and the small effect they had on him and his party: "The rebels sprung their rattles, rang the bell, and commenced firing, at the same time repeating their hail, and seemed much confused." And again—"Three bullets struck my clothing, and the air seemed full of them. The result of all this firing was—"the most of our party were captured, some drowned, and only one escaped besides myself, and he in a different direction." But he makes no mention of any having been shot.

The question is often asked, What is the best kind of torpedo for these boats? and it is a difficult question to answer. For the 57 ft. sizes, such as supplied to the Scandinavian Governments, and the 67 ft. boats, such as applied to the French Government, I should say that either the outrigger, or a modification of the Harvey torpedo, is the best, as these boats could not carry the Whitehead torpedo, with its launching and air-compressing gear. The Harvey torpedo might be used for the larger class of vessels, but I think the outrigger and the Whitehead torpedo are the preferable weapons. The Whitehead is generally considered the safest torpedo to use; but if the men have to expose themselves on deck, even at 500 yards' distance from their enemy, while discharging it, I almost fancy it would be better to have them all under cover, and run the extra risk from the larger missiles, and to go close alongside, with the outrigger torpedo. The operation would, I think, be more certain in its result. As an illustration of what may be done safely in going alongside and attacking large vessels, I may instance the

daring attempt to sink the United States steamer Minnesota, by Captain Hunter Davidson, of the Confederate navy. This officer proceeded from Richmond to Hampton Roads in a small steam launch, armed with a torpedo containing 60 lbs. of gunpowder. Leaving Richmond in the evening, he traveled all night, and during the day hid himself and his vessel in a creek. He arrived in Hampton Roads the next night, and in going alongside the Minnesota he was hailed, and ultimately fired at; but such was the confusion that he not only succeeded in exploding his torpedo, but in escaping safely back to Richmond, although firing and signalling were going on in all directions, and his engineer could not get his engine (a single cylinder one, which would hang on the dead center) to start for some considerable time after the explosion of the torpedo. I believe the best defence against attack from these torpedo boats is to have other and similar boats steaming round the vessel to be protected, ready to ram or otherwise destroy the attacking boats. Possibly some modification of the hand grenade might be used for this purpose. Such guard-boats should have as much speed as the attacking boats, and arrangements should be made for hoisting them on deck, when they are not required for guard duties. We have designed some small-sized boats for this purpose, but I think the 57 ft. type is quite small enough for sea work, and her weight of 7 tons is not a difficult problem to grapple in the way of hoisting. The principal danger run by our boats is, undoubtedly, that of being sunk, and I have thought, for some time past, that it would be better to abolish the thick bullet-proof plating in their construction—excepting that immediately over the engine room—and to use ordinary plating instead. The weight saved could then be used in the bottom, in the form of half-bulkheads, sufficiently high to reach above the water line at every third or fourth frame along the bottom. If a shot penetrates the boat, it does not follow that any of the crew will be struck by that particular shot; but it does follow that if the shot goes through the bottom water will enter, and, unless the quantity is limited, the boat will sink. The half-bulkhead protection limits the quantity of water that will enter, and I should say there would be no difficulty whatever in plugging up the hole made, and afterwards pumping the water out by means of the bilge pumps.—*Engineer.*

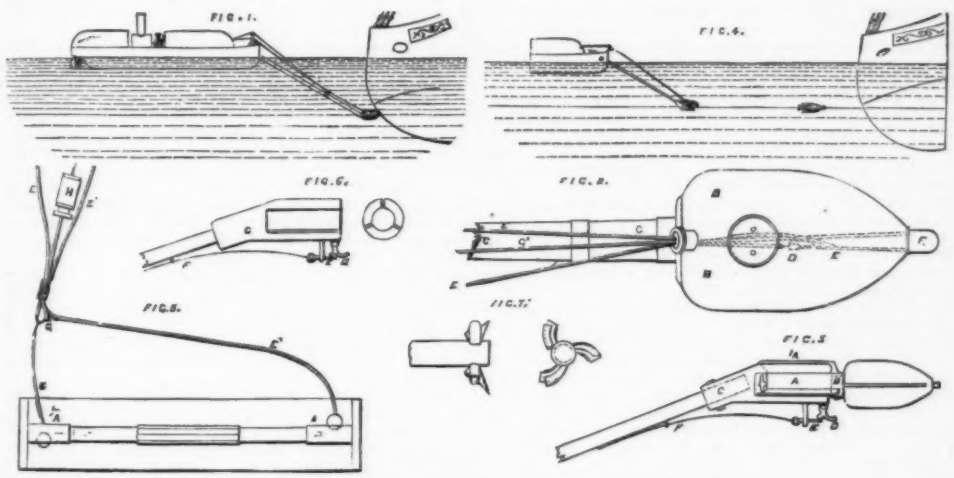
IMPROVED SPAR TORPEDO.

By this method, with a single platinum fuse and battery and one set of wires, the torpedo can be fired either on contact or at will, as desired. Referring to the drawings, AA, Fig. 3, is a top view of the box containing the battery; B, the torpedo, carried at the end of the spar C; D is a platinum wire, or other electrical fuse, in the interior of the torpedo; E, E¹, are two wires leading from the opposite poles of the battery to a contact maker, F, on the nose of the torpedo, by which contact is made between the wires whenever the torpedo is touched by the vessel attacked, and the current thus being free to pass through the fuse D, acid, and the latter, escaping into the reservoir A, produces a fluid under pressure, which is caused to propel the torpedo as before described. Fig. 7 shows the form of a screw propeller capable of being driven in this manner.—*Engineer.*

LIGHTING STREET LAMPS BY ELECTRICITY.

MAYOR PRINCE, Alderman Slade, and other gentlemen of the Boston city government, have been here inspecting the system of lighting the street lamps by electricity, which has been successfully introduced by the Electric Lighting and Telegraph Company. It should be stated at the outset that the system here in use is entirely different from those which have been tested in Boston and other cities without success. Hitherto attempts have been made to operate the stop-cock connected with the lamps and light and extinguish the gas by means of electricity. This method proved a failure chiefly because the faulty working of the stop-cock, which fact of course vitiated the whole system. The objections to this plan have all been obviated by the Electric Lighting Company. Instead of attempting to operate the stop-cock by the agency of electricity, compressed air is used, thus making the turning on of the gas and lighting it by electricity two entirely separate and distinct operations. By this process all the operations are conducted in clock-work order, and the failures in lighting the lamps in this city for six months have been less than one-fifth of one per centum, and the failures in extinguishing them have been less than one-fiftieth of one per centum, reckoning in both these estimates all defects arising from the clogging of the gas burners, leakage of pipes, breakage of lanterns, and other mishaps which are inevitable even under the system of lighting by hand.

The process by which the lamps are lighted and extinguished is exceedingly simple. All the lamps are connected with a battery by an underground wire running through an airtight tube, which is attached to an air-pump. This tube is half an inch in diameter, and is laid fifteen inches below the surface of the streets or sidewalks. By a simple operation of the air-pump the stop-cocks connected with all the lamps are opened or closed, and by a single touch of the key connected with the electric battery the lamps for a circuit of any length, be it one mile or one hundred, are lighted in an incredibly short space of time. If, for any cause, a lamp in the circuit fails of lighting or extinguishing, an indicator connected with the battery points out the number of the lamp so failing and another touch of the key remedies the defect at once. These failures are of such exceedingly rare occurrence, however, as has already been shown, that but little or no importance is attached to this feature of the system. The cost of keeping the apparatus in running order and in good repair is scarcely appreciable, a matter of thirty or forty dollars being sufficient to keep up the works for a year. The services of one person amply suffice for conducting the entire work, and the only extra labor required is for keeping the lamps properly cleaned.



IMPROVEMENT IN SPAR TORPEDOES.

the torpedo is thereby exploded. The wire E has, leading from it near the battery, a branch wire G, which passes to a contact maker H, and from this contact maker a wire, G¹, is led with the other wires E, E¹ to the torpedo, and it is coupled to the wire E¹ between the fuse D and the contact maker F. When an electrical communication is established between the wires G, G¹, by means of the contact maker H, a current will likewise be passed through the fuse, and the torpedo caused to explode. But with every system yet invented of spar torpedo, it is necessary that the torpedo boat shall approach so closely to the hostile vessel that there is always danger of being swamped by the explosion which she creates against her adversary, and this liability to being "hoist by her own petard" will generally make attacks by torpedo boats resemble very much a forlorn hope, to be undertaken by men with the probability of death staring them in the face. The locomotive torpedo shown in Fig. 4, which is an adaptation of the fish to the spar, has been invented by Captain McEvoy with the idea of lessening this danger in spar torpedo attacks. This is done by providing the torpedo with locomotive power sufficient to carry it a short distance, say a hundred yards, which he effects by placing inside the torpedo a reservoir of water containing a carbonate, and a flask of acid which can be broken when desired by a trigger pulled from the boat by a lanyard. The fluid, under pressure thus produced, is used to give motion to the torpedo, either by allowing it to escape through a hole at the rear, or by directing it through tubes in the blades of a screw propeller so arranged that the pressure of the fluid forced out of the torpedo through them will cause the blades to revolve. It is not, however, necessary to employ a chemical mixture as air or other fluid under pressure would produce the same results. The details of this plan are shown in Figs. 5, 6, and 7. A is the reservoir fixed to after-end of the torpedo, filled with water containing the carbonate, and B is the flask of acid. On the exterior of the reservoir are radial webs, A¹, to prevent the torpedo itself from revolving. The torpedo, when required for use, is put into the holder C at the end of the spar. This holder—shown in Fig. 6—carries a hammer D, retained by a pin E. When the pin is withdrawn by pulling the line F, the hammer breaks the flask of

The company agree to furnish the battery, the air pump, laying the underground wires and the entire apparatus necessary for conducting the work at an expense of $50 per lamp. The company guaranteed to effect an annual saving to the city of $15,000 for the two thousand lamps in the city, or a *pro rata* saving on any smaller number of lamps that were given them. This necessitated an actual saving in the amount of gas used and in the labor of lighting of $7.50 per lamp, but as the contract covered six months only, and called for the lighting of only two hundred and twenty of the two thousand lamps, the company was thus bound to show a saving of $825 for the period covered by their contract or forfeit all claim to reimbursement. This saving appears preposterously large at first thought, but when it is remembered that the services of lamp-lighters are dispensed with, and what is still more important, that the lamps are all lighted in an instant when it is dark instead of half an hour or more before gaslight is required, as is invariably the case under the method of lighting by hand, the guaranty appears a reasonable one. That the experiment has been a successful one in every respect, and that the company has made good its boast, is shown by the fact that upon the expiration of the six months the city paid the company for its work, and an offer, based on precisely similar conditions, to light five hundred more lamps, is now before the city government, and will doubtless be favorably acted upon. A saving of over $3.25 per lamp was realized by the city during the six months.—*Providence Letter to Boston Post.*

M. JABLOCHKOFF'S ELECTRIC CANDLE.

A NUMBER of visitors lately assembled at the West India Docks, London, to witness certain experiments to be performed with M. Jablochkoff's electric candle. The experiments as far as they went were perfectly successful. A yard, 150 feet by 70, surrounded by buildings on three sides, and covered with an awning, was perfectly well lighted with four "candles," pearl type being legible at any part of the covered area. The applicability of the light for illuminating warehouses, wharves, and ships' decks, as well as its portability within a limited space, were also well shown. The light is white and soft, although brilliant, and in general tone and quality closely resembles the limelight or the brilliant moonlight of the south of Europe. The light is not perfectly steady, although it does not flicker nearly so often or so violently as the best form of electric lamp with which we are acquainted. We prefer, however, to reserve any fuller criticism until the experiments are repeated in proper form. Suffice it to say that M. Jablockhoff has fully proved that a fairly steady and brilliant light may be produced by his "candle" fully applicable to the purposes we have named. He has also proved that the current from one machine may be divided into several, each available for a single light, which is one of the most important discoveries which has been made with respect to the electric light for some years.—*Chemical News.*

SPECTRUM ANALYSIS.*

By PROF. REDWOOD.

AMONG natural phenomena there are none more calculated to excite our admiration and wonder than those presented by the rising or the setting sun, by a rainbow, and by the sky on a clear starlight night. An intelligent observer of these phenomena cannot fail, at some period of his life, to have indulged in speculation as to what the objects presented to his observation are, and how they have been brought to his perception. He has been told that for all his ideas of things that are beyond his sense of touch he is indebted to an agent, itself invisible, which is the medium of communication between his organs of vision and objects which may be separated from him by distances either small or immensely great, extending even into the abyss of fathomless space. He has learnt that the chief source of this wonderful agent, which we call light, as far as we are concerned, is that glorious orb which shines upon us by day and leaves us in comparative darkness by night. He may have been told that the sun is distant from us about 92,000,000 of miles, a distance which, Sir John Herschel says, a cannon ball would occupy seventeen years in traveling, yet that such is the velocity with which light travels, that it performs the same journey in eight minutes, its rate of traveling being about 190,000 miles in a second of time. He knows, for it is a matter of common knowledge which is sown broadcast in these days of extended education, that philosophers have constructed theories to explain the phenomena referred to, and to account for the way in which they are brought within our perception; that by some philosophers light has been supposed to consist of particles of a particular kind of matter, infinitely small, emitted from luminous bodies, darting through space in straight lines, striking against, rebounding from, or penetrating and sometimes passing through, those bodies which lie in its way—this being the theory of Sir Isaac Newton, which has been known as the corpuscular theory or theory of emission: while other more modern philosophers, with what is now considered to be stronger evidences in their favor, assume that light is not a sort of matter but a condition of matter, that it is caused by a tremulous or vibratory condition which bodies assume when they become luminous, and that this vibratory condition is communicated to and propagated through an ethereal medium which fills all space, has a high degree of elasticity, and is so greatly attenuated that we have no evidence of its being affected by gravitation—this being known as the wave theory of light.

Now, there exists a very close relationship between light and heat and chemical action, which necessarily brings the study of all these subjects into the department of chemistry.

Chemical action develops heat, and heat develops light. So also both heat and light induce chemical action.

We have a good illustration of the development of light from heat in observing what occurs when we send a current of electricity through this wire. The wire first becomes hot, and then it becomes luminous, the light increasing with the increase of temperature.

And we have a good illustration of the development of heat by chemical action in this little jet of flame produced by the chemical combination of hydrogen and oxygen gases. But here at present we have no evidence that the heat produces light, for although the heat of this flame is as great as the heat of that wire, the light emitted from them is very different. The one is brilliantly luminous, while the other is practically invisible. This difference is due to the fact that light can only emanate from the solid particles of matter, and the denser the matter—that is, the greater the number of particles in a given space—the greater will be the amount of light produced by the heating of such matter. There are very few solid particles in this gas flame, and therefore it gives very little light; but if I introduce solid particles by putting a platinum wire into it, the heat which is already in the flame when communicated to the wire renders it as luminous as the other wire.

Having thus associated heat with chemical action and light with heat, we may say, in accordance with accepted theories of modern science, that not only is heat a mode of motion but that light and chemical action are so also.

Now, as we shall be chiefly engaged this evening in examining and studying some of the phenomena of light, it will be well to commence by considering what the mode of motion is by which we may account, and by which physicists are accustomed to account, for light in some of its various conditions.

In doing this, it is essential for our purpose to assume that no such thing exists in the universe as a perfect vacuum. We may also assume that no such thing exists as absolute solidity or continuity of parts in any form of matter except those particles or atoms of which bodies are composed. Masses are made up of atoms, but there are spaces between the atoms which, in common with all other space, are filled with the ethereal medium which we call the luminiferous ether. This ether is so infinitely attenuated that, as I have already said, we have no evidence of its being affected by gravitation, yet it possesses a very great degree of elasticity.

It is necessary to assume that the ether that fills the spaces between the atoms of bodies acquires increased density there, but that it does not acquire proportionately increased elasticity. In consequence of this change of density in the ethereal medium which fills the spaces between the atoms of transparent bodies, light travels through such bodies with velocities which are diminished in proportion as the densities of the bodies are increased.

This result accords with what is known to occur in the case of sound, the velocity of which increases with the elasticity, but diminishes with the density of the medium through which it is propagated. Now, if the luminiferous ether in transparent bodies had its density and elasticity increased so as to maintain their proportions unaltered, the one would exactly neutralize the other, and there should be

* Lecture delivered before the Pharmaceutical Society of Great Britain, May 2, 1877.

in that case no alteration of velocity; but by assuming that its density is increased to a much greater extent than its elasticity, the observed effects of the transmission of light through different transparent bodies is easily accounted for.

It is to the alteration in the velocity of light when it passes from one medium into another of different density that we ascribe the refraction or bending of the rays; and it is by means of refraction that we shall be enabled presently to effect the analysis of light.

Light, then, is a state of motion of the luminiferous ether, originating in a condition of motion of bodies which, when they are in that condition are said to be luminous.

The grosser forms of matter, which are distinguished from the luminiferous ether by their being affected by gravitation, are capable, under the influence of heat, or electricity, or chemical action, of exciting the luminiferous ether, and throwing it into a tremulous or vibratory condition.

This vibratory condition of the ether is itself imperceptible to us, except when a continuous line of such vibrations reaches the retina of the eye from either a luminous or an illuminated body, the latter being a body which, instead of originating light by exciting the luminiferous ether, merely changes the direction in which a line of vibrations or ray of light is traveling; and when any of these rays impinge upon the retina of the eye they render the object from which they proceed visible, that is to say, they excite motion in the optic nerve which communicates with the brain, and produce a sensation or image.

Now, we have to deal with the luminiferous ether, and to consider what kind of motion the ether undergoes in the propagation of light. In doing this, we must first assume that the ether itself is composed of parts or particles infinitely minute, which are held in their normal state by a force which gives to it great elasticity, but admits of the particles moving to and fro through infinitely short distances, with almost inconceivable rapidity.

If we compare the transmission of light with that of sound, taking for granted the conclusions arrived at by physicists, we shall find that there is a marked difference between them. In both cases the effect is due to vibrations. In the case of sound, it is due to vibrations that are propagated through a material medium, usually through air. In the case of light, it is due to vibrations through a medium which is independent of the recognized forms of material matter.

The vibrations to which sound is due consist in the movement to and fro of particles or little volumes of air in the direction in which the sound travels. The vibrations are *longitudinal*, in a line coinciding with the direction of the sound.

On the other hand, the vibrations to which light is due consist in the movement to and fro of particles of the luminiferous ether in a direction *transverse* or at right angles to that in which the light is traveling.

If we assume the existence of a line of particles of the ethereal medium in a quiescent state, and conceive a luminous body, such as a candle, to be the source from which light is to be propagated through such particles by throwing them into a state of vibration, we may readily suppose that the particles would begin to move, not all at once, but progressively one after another, commencing with the particles nearest to the luminous body. The first particle would begin to move before the second, and the second before the third; and as they would all move to the same extent, to and fro, across the line of light, the position of the particles when in motion would necessarily represent a series of waves.

But the idea thus formed is that of motion or vibration of the particles in one plane only, and it is necessary to assume a more complex mode of motion than this in a ray of common light. It is assumed that the plane of vibration is constantly shifting, that there are a few vibrations in one plane, then a few in another plane, and so on as the ray travels along, this shifting of the plane of vibration occurring very irregularly, but occurring in all conceivable planes around and through the line originally formed by the particles in their normal state of rest.

A round ruler, or this model, may be taken to represent or afford a rude idea of a ray of common light.

But it is now necessary for us to endeavor to dissect this ray of light, and we are enabled to effect this dissection or analyzation of the ray by taking advantage of the effect produced upon it on causing it to pass through transparent bodies of different densities.

At the moment of its passing from one medium to another of different density, if it enters the new medium in a direction oblique to the surface at which it enters, it is bent or *refracted*, and when it is refracted at two surfaces which are not parallel to each other, as, for instance, in passing through a prism of glass or other transparent substance, the different parts of which the white light is composed are to some extent separated from each other, and we thus find that the separate parts possess color.

This, which is prismatic analysis of light, is the first step we take in the direction of analyzation. We are here pulling the elements of light asunder, so that we may examine and study the separate parts of which it is composed. The result of this *dispersion*, as it is called, of a ray of light is the production of the *spectrum*, in which we have the colors of the rainbow painted on the screen with a brilliancy far surpassing anything we can produce by the use of artificial colors or pigments.

Now, the question is, what do these colors signify, and what is the difference between one color and another?

The answer to this question is, that these are effects resulting from the greater or less rapidity with which the vibrations occur, and the conclusion arrived at is, that a ray of common white light is composed of several sets of vibrations traveling together with equal velocity, but each set consisting of vibrations differing in frequency or rapidity from the others. The vibration of least frequency are those at the red, and those of greatest frequency are those at the violet, end of the spectrum.

Each of these sets of vibrations forms a separate series of waves, and these waves differ in length just as the vibrations from which they result differ in frequency; the least frequent vibrations produce the longest waves, while the most frequent vibrations produce the shortest waves.

Prismatic analysis was first studied by Sir Isaac Newton, who, admitting a beam of sunlight through a round hole into a darkened chamber, obtained by means of a prism an oblong image of colored light on a screen, and the image thus produced presents seven distinct colors, which are known as Newton's prismatic colors. But the spectrum produced in that way is not now recognized as a pure spectrum, because the colors overlap each other, and thus produce intermediate colors.

Dr. Wollaston, at a later period, obtained a much nearer approach to a pure spectrum, by admitting the light through a narrow slit. In this case the spectrum is a long band or ribbon of light, the colors of which may, by narrowing the slit, be reduced to four, namely, red, green, blue, and violet.

Several suggestions have been made with the view of simplifying the mode of representing the composition of white light. It is now generally assumed to consist of three elementary colors, and these have very generally been supposed to be red, yellow, and blue. Sir David Brewster adopted this view, and the observation of the results of mixing artificial colors or pigments appears to justify the opinion that Newton's prismatic colors may be all produced with red, yellow, and blue. But the study of colored lights produced by the prismatic analysis of white light leads to a different conclusion.

Wollaston reduced his spectrum to four colors, namely, red, green, blue, and violet, and he found these to bear the quantitative relation to each other of 16 parts of red, 23 of green, 36 of blue, and 25 of violet, in 100 parts.

Dr. Thomas Young, one of the highest authorities on the subject, recognized three simple sensations as those produced by a ray of white light, these sensations when separated being those of *red*, *green*, and *violet*, and it has been shown that not only can white light be produced by the union of those three colors, but that orange and yellow can be produced by the union of green and red, and that blue and indigo can be produced by the union of green and violet.

We therefore take red, green, and violet, as the three elementary colors from which all others may be produced.

I must refer you to the diagram which represents what are assumed to be the number of waves that are formed within the space of an inch, and the number of vibrations that occur in a second of time, in each of the elementary colors.

Waves of Light.

	Waves in 1 inch.	Vibrations in 1 second of time.
Red	34,000	482 millions of millions.
Green	45,000	550 " "
Violet	60,000	707 " "

Now, we have produced our spectrum by Dr. Wollaston's method of passing the light through a narrow slit, but we have not the advantage here that he possessed of employing the light of the sun. We are using the best representative of sunlight that we can command, namely, the light of incandescent charcoal brought to an intense heat by a current of electricity. The luminous body from which this light emanates consists of solid carbon which forms the terminals of the conducting wires of a Groves' battery of 40 cells. These carbon terminals when brought together touch each other only at a few points and thus offer obstruction to the free passage of the electric current; heat is therefore developed; the carbons become hot, and if they be now gradually separated to a small distance from each other, the current is maintained, an arc of light fills the space between the two points, through which small particles of incandescent carbon are constantly flying from one terminal to the other, while the points themselves being intensely heated are the source from whence our light emanates. The magnified image of this is thrown on to the screen, so that you there see the whole mechanism of the production of the light.

I will now shut off the light which has been passing from the lantern in a direct line to the screen, and, sending it in another direction through two prisms, filled with bisulphide of carbon, will cause it to travel round a corner and so reach the screen by a different route. In passing through the prisms the light is turned from its original course, and it is largely dispersed in consequence of one part of it being refracted more than another, the bisulphide of carbon contributing to the dispersion.

We thus produce our spectrum, which you will observe is a continuous band of light, of different colors, but without any interruption of light from one end to the other.

This is the result always obtained when the luminous body from which the light is derived is either solid or liquid. But it is not the result obtained with the light of the sun.

It was Dr. Wollaston who first, in 1802, discovered, on closely examining the nearly pure spectrum of sunlight, which he obtained by adopting his method of prismatic analysis, that there were several dark lines running across the spectrum and interrupting its continuity. These lines are not seen in Newton's spectrum, the effect being there obscured by the overlapping of the colors.

Afterwards, Fraunhofer, of Munich, in 1814, by increasing the length of the spectrum and using a telescope, was enabled to trace about 600 of these dark lines, which are now called Fraunhofer's lines.

I must refer you to the drawings for a representation of these dark lines. There is no difficulty in detecting the more prominent of them in the solar spectrum, but it long remained an enigma as to what was their cause.

We have reason to believe that this enigma has now been solved; but before attempting to explain the manner in which the phenomena of Fraunhofer's dark lines are accounted for, I purpose bringing under your notice the spectra produced by some other lights besides that I have hitherto employed.

I have already alluded to the fact that the light emitted from luminous bodies, when in the solid or liquid state, yields spectra which are continuous throughout the illuminated band, the light consisting of rays of all degrees of refrangibility within the range of the two extremes.

To this must now be added the statement that if the luminous body be in the condition of a gas or vapor, the light emitted by it may consist of rays of several limited degrees of refrangibility, which will produce a spectrum consisting of one or more bright bands of colored light with intervals more or less completely dark.

Any substance that can be converted into a luminous vapor may in this way produce a spectrum peculiar to itself, and we thus have a means of identifying substances and of detecting their presence when existing in a state of admixture with other substances, which in many cases is of great value to the chemist.

It will be perceived that we are here entering upon the practical part of the subject of spectrum analysis.

With a little modification of our lamp we shall be able to make the intense heat produced by the electric current a means of converting some of the metals into vapors of sufficient luminosity to yield spectra that may be projected on to the screen.

In doing this we shall work with the carbons a little wider apart than we have hitherto had them, so that the arc of flame between the points, rather than the points themselves, should be the source of light.

We use a large carbon now for the lower terminal, and the end of this is hollowed out so that it may support the bit of metal which is to be heated by the electric current until it melts and is converted into vapor, which will give color to the flame and also a characteristic spectrum.

My son, who has taken charge of the lamp, which requires rapid and skillful manipulation in the experiments we are going to perform, will make the necessary adjustments for producing the required effects, while I endeavor to explain the results.

The first metal I propose using is thallium, which the President has had a good deal to do with, especially in the production of its compounds. This metal owes its discovery to spectrum analysis, and it yields a very distinct and beautiful spectrum. On heating some of it in the electric lamp, it is converted into a beautiful green vapor, which fills the space between the carbon terminal. By allowing the light to pass directly from the lamp to the screen you are enabled to see the carbon points which are now less heated and less luminous than they were in previous experiments, the electric current being more freely transmitted by the metallic vapor than it was by the incandescent carbon alone. The green vapor of the thallium, so beautifully painted on the screen, forms an arc of light, some rays of which, by stopping their direct passage to the screen, and allowing them to pass through the slit and the prisms, are gathered up into a single band of green light, which forms the spectrum of this metal.

We now remove the carbon cup in which the thallium has been heated, and introducing a fresh carbon cup, subject a bit of silver to the same treatment. It melts and boils, emitting a vapor which, as you will perceive, is not distinguishable in color from that of the thallium vapor. But if we now stop the direct passage to the screen, and send the light through the prisms, we obtain a spectrum which differs from that of thallium, inasmuch as it consists of two green bands instead of one, and these do not occupy exactly the same position as the thallium band did in the space that would be occupied by a continuous spectrum of white light.

Removing the silver with its carbon support, we will now introduce copper, which, treated in the same way as the other metals, yields again a green vapor, the spectrum of which, however, is distinctly different from either of those previously obtained. We have now three or four bands of red, several of green, and also of blue.

Changing now again the carbon support on which we have had the copper, we will next introduce a bit of zinc. The color of the bright vapor of this metal as it is thrown directly on to the screen, you will observe, is a beautiful violet. Remark the splendor of the luminous arc of violet light, which we can increase to some length by separating the carbons, as the metal freely volatilizes and carries the current of electricity from one pole to the other forming a bridge of colored light. But we must now close that passage from the lantern, and send the rays by another route to be analyzed by the prisms, and to have the component parts of the light gathered together and displayed on the screen as the spectrum of zinc. You will see that it consists of a red band, and three very beautiful blue bands, wholly distinct and different from anything we have had before.

Following copper and zinc, we will now introduce a bit of brass, and here we shall see that the spectrum of this metal at once reveals the elements of which it is composed. We have the characteristic bands both of the copper and the zinc, showing the power of this method of analysis for indicating the component parts of compound bodies.

I have now only one more metal to bring under your notice, namely, sodium. This metal gives a very characteristic yellow band, which is easily produced, but I fear we shall not be able now to produce it in a state of purity on account of the atmosphere of our lantern having so much volatilized matter from the metals we have been already operating upon. I am anxious, however, to show the bright yellow sodium band, and will ask you to disregard some of the other bands, which will appear with it, and which are caused in the way I have stated.

It is this yellow sodium band that we are going to endeavor to convert into a dark band, and failing the accomplishment of that result I should have failed to demonstrate one of the principal objects I have had in view, namely, that of showing that the bright bands which characterize the several metals, and which you have seen, may be converted into dark bands.

It has been found, by very careful and accurate admeasurement of the positions occupied by the bright bands in the spectra of many of the metals as compared with the solar spectrum, that the bright bands in the one correspond with the dark bands in the other. It has also been shown that when light of a high degree of luminosity passes through a luminous atmosphere of lower illuminating power, the one light may absorb out of the other that portion of light which corresponds in refrangibility with its own. This result has been proved experimentally and explained theoretically, but time will not admit of my entering minutely into this part of the subject on the present occasion.

I must, however, endeavor to show you that if we introduce the vapor of sodium into the flame of a Bunsen's lamp, in front of the slit from which the light of the carbon points is issuing, and then allow the light to pass through the prisms, the spectrum so produced will have a dark band in the place of the usual bright sodium band.

This reversal of the bright bands of the spectra of the metals, and the establishment of the coincidence of such bands with dark bands in the solar spectrum, was the great discovery of Kirchhoff, which not only affords an explanation of the cause of the dark lines in the solar spectrum, by assuming that the sun consists of a solid or liquid nucleus in a highly heated state with a luminous atmosphere surrounding it, but it indicates that we have the means of detecting, and that Fraunhofer's dark lines prove, the presence in the sun's atmosphere of certain metals, including those, with one or two exceptions, which we have been using this evening.

By spectrum analysis, therefore, we are enabled to reveal the composition of substances within our reach and to detect the presence in them of elements which may be there in such minute quantities that they cannot be discovered by other means, and we are also enabled in the same way to investigate the composition of bodies so far distant from us as the sun and even some of the fixed stars, the distance of which is vastly greater than that of the sun, for it has been calculated by astronomers that a ray of light cannot reach the earth from the nearest of the fixed stars in less than five years.

Nor does the power and application of spectrum analysis terminate here, for, as I will now show you, when a ray of white light is made to pass through substances in solution such as chlorophyll, the coloring matter of cantharides, lobelia, etc., part of the light is often absorbed so as to yield spectra with dark bands, which are sometimes characteristic. A large number of results of this description have been obtained which are interesting and may prove to be of value in analytical researches.

[ENGINEERING NEWS.]

MOVABLE DAMS.

IT is only quite recently that movable dams have been proposed in the United States for the improvement of the Upper Ohio and the Kanawha rivers, where it is desirable to make them deep enough to carry coal barges and rafts at low stages of water; and we think that few American engineers have a very clear idea of the details of such a construction and the methods of working. These dams have been introduced extensively upon French rivers, notably the Seine, the Yonne, the Marne, etc., as well as elsewhere, but as accounts of the structures built from time to time have been found heretofore only in the *Annales des Ponts et Chausses*, they have not been accessible generally to inquirers in this country. It appears that as long ago as 1818, Josiah White built a movable dam on the Lehigh river which was manœuvered solely by the pressure of the water; it consisted, we believe, of two gates, turning about horizontal axles at their lower ends, the up-stream gate slanting down stream, resting upon and being supported by the lower one which inclines up stream. If the water between and below the two gates was permitted to escape, they revolved on their axes, falling one on the other, and leaving the passage open. This device is known as the "bear-trap." This dam was destroyed in the course of time and has well-nigh been forgotten.

For some fifty years various modes of constructing movable dams have been tried in the European rivers, and many of the plans are very successful. Shutters turning about hinges at the bottom, wickets which revolve about horizontal axes a certain distance up, needles or bars removable by hand, caisson dams, etc., are to be found, some worked by hand, some by gears and chains, and some by hydraulic presses directly applied; in fact, the number of modifications reach some dozen or more. Perhaps the most accessible source of information are the reports made to the Chief of Engineers, U.S.A., by General Weitzel and Colonel Merrill, in the years 1874, 1875, and 1876, which give liberal extracts from foreign writers with plans and details. The report of the U. S. Commission to the Vienna Exhibition also contains an interesting account of two such dams.

Hagen, a prominent writer on hydraulics, in discussing the uses of movable dams and their importance, says:

"A complete solution of the problem seems to require that the pressure of the water, whether standing or flowing, should furnish the power by which the dam is erected or removed. Or, again, the construction must be such that, notwithstanding the requisite solidity of the structure, it can be managed with a slight power, for which only a few men and short time are required."

These dams are generally associated with locks to provide for the navigation up stream, and are sometimes intended to furnish a slack-water navigation of sufficient depth at low stages of the river. In this case the dam is only removed at times of comparative high water. But, in other cases, they are dropped to allow the passage of a number of barges, and closed again to cause the pond to fill. The barges then go rapidly forward on the artificial wave or flash which is created, and are thus carried in safety over what would be, otherwise, bars and shoals. One very curious circumstance is that the front of the wave, rolling over, as it were, travels faster than the remainder of the flash, so that the boats in advance can make a short stop at a landing below and still take the same wave again.

Hon. F. R. Brunot, of Pittsburgh, has devised a floating hydraulic gate which was recommended for trial in one of the dams of the Monongahela Navigation Company, and some description of this design may be found in the *Franklin Institute Journal*.

The construction of dams for the improvement of the Great Kanawha river is now in progress, although the deficiency in appropriations this year will retard the work. There are to be twelve dams in the 92 miles from its mouth at the Ohio river to Great Falls. In nine of them there will be passes, with movable wickets, opening a clear passage of 250 feet in length. Seven feet of water will be secured when they are closed, and the lift of most of the dams will also average 7 feet. The three upper dams have a lift of 15 feet each and no movable portion.

As a type of the low lock and movable dam, we copy the description, given by the Chief of Engineers in the Report for 1876, of Dam No. 5, of Brownstown, some eight miles above Charleston, and now under construction:

"The lock, which is 364 feet in total length, 300 feet between hollow quoins, and 50 feet in clear width, is designed to pass at one lockage four coal barges of the dimensions usual on the Ohio and Kanawha rivers; that is, 130 feet long, 24 feet wide, and drawing 6 feet of water. It is placed in the river as near to its left bank as practicable, while giving a good exit and entrance for boats. The dam, about 560 feet long, crosses the river at right angles to its direction, opposite the lower abutment, with a height from the rock of about 17 feet, and will raise the water nearly 11 feet above low water. The pass adjoins the lock, is 250 feet wide, and its floor is 50 feet long in the direction of the stream. The pier which separates the pass from the weir is 13·5 feet wide, 48 feet long, and 4 feet higher than the dam. The right bank of the river is protected by a masonry abutment, rising 10 feet above the dam, with wings extending to the top of the bank, above the reach of overflow.

"The lock walls will rest upon the rock, which at this point is between 3 and 4 feet lower than the miter sills. At the ends (the abutments for the gates) they will have a thickness of 16 feet, the interior faces will batter ¼ of an inch to the foot, the exterior faces will be vertical on the river side, while the back of the shore wall will batter 2 inches to the foot. Between the ends or abutments, the chamber walls are 12 feet thick at bottom of lock and 5 feet at top, the whole height being 20 feet; depth of water, 7 feet, and lift of the lock, 7 feet. The top of the lock is therefore 6 feet above the top of the dam.

"The upper and lower miter sills are placed on the same level, so that, by opening all the gates, the lock may serve as an extension of the pass. The miter sills are of stone, faced with timber; the floor of the lock is of concrete, covered with plank, except a space below each gate, which is paved with dressed stone. The angles, hollow quoins, miter sills, coping, etc., are of cut stone; the rest of the masonry will be of a much cheaper class, although not inferior in fitness, strength, or durability, all to be laid in the best manner in hydraulic cement. The chamber walls will be furnished with wings for the purpose of securing boats. The lock will be filled and emptied through valves in the gates, in addition to iron culvert pipes passing around the hollow quoins. It is proposed to build the gates of iron frames, covered with an outer sheathing of plank.

"In the lower abutment on the river side is a well containing the earing for tripping or throwing down the wickets of the navigation pass. This, as well as the chain wells and gearing for operating the gates, is contained below the surface of the coping, and covered by iron plates; for, as the lock will be submerged in floods, it is necessary that no machinery or framing should be exposed on the top of the walls.

"The floor of the pass is about three feet above the rock foundation. It is formed of concrete, supported front and rear by timbers framed into crib-work, the top is furnished with large timbers arranged to hold the journals, slides, etc., which are attached to them, and paved between the timbers with stone.

"The wicket is a wooden frame 13' 6" high and 3' 8" wide, covered with planks, and capable of revolving about an axis placed at the middle of its height. This axis is formed by the crosshead of an iron frame or horse which is itself movable about a horizontal axis fixed upon the floor. When a wicket is raised its foot rests against the sill of the floor, its horse is maintained vertical by an iron prop, the foot of which abuts against a heurter, an iron abutting-piece fastened to the floor.

"The wickets, being placed side by side across the current, form, when raised, a dam to close the pass. A movable foot bridge is constructed up stream of the wickets, across the pass, to facilitate the operations of opening. To throw down or open a wicket, it is necessary to pull sidewise the foot of the prop, so that it shall slide across and clear the front of the heurter. The prop, having lost its support, slides upon the floor down stream, the horse at the same time turns about its axis and falls upon the floor, the wicket follows them, and covers and protects the other pieces.

"If there is no water upon the floor, the wicket would be broken by the fall, but a very shallow cushion of water is sufficient in a great measure to destroy the shock. The foot of the prop is pulled away from the heurter by means of the tripping bar, one end of which carries a rack gearing into a pinion in the well in the lock wall, worked by a crank on top.

"To raise the wickets, the lock keeper stands upon the foot bridge, and by means of a portable winch pulls up a chain attached to the foot of the wicket. The wicket rises, maintaining, however, a position nearly horizontal. It offers, therefore, but little resistance to the current. The horse and the prop follows its ascent until the foot of the latter, passing over the inclined plane which forms the top of the heurter, falls in front of it at the same time that the horse attains a vertical position. The axis of the wicket is now in its fixed position, and a slight push on the foot of it, or even the slacking of the chain, is enough to cause it to right itself and bear its foot against the sill."

NOTES ON THE TREATMENT OF SEWAGE AT MANCHESTER, SALFORD, AND BIRMINGHAM.

By P. LE NEVE FOSTER, M.A.,
Secretary of the Society of Arts.

FROM the special condition of its locality, Manchester has but small facilities for the water-carriage of its sewage; and the problem has been how best to deal with the subject without having recourse to that mode of treatment. There are some 67,000 houses in Manchester, and only 10,000 water-closets; it is not unreasonable, therefore, that the treatment of this branch of the system should be deemed of secondary importance, and that the object of the authorities has been to deal with the larger portion which has hitherto been principally served with ash-pits, middens, privies, and the like. These, however, under the active operations of the Corporation, are fast passing away, and their places being taken by improved cinder-sifting closets, which under compulsory powers are superseding the old system. At the present time there are 28,000 closets on the cinder-sifting principle, and 14,000 of the old midden closets still remaining. These latter, however, are gradually being got rid of, and the improved closets substituted in their stead. The change is taking place at the rate of about 200 per week, and it is expected that this rate will increase, and that the whole will be converted in a year and a half from this time. This closet is either put up by the owner, or the Corporation supplies the closet complete for £4 4s. Under the seat the fæces and urine are received in a special metal or wooden pail or tub. By the side is a cinder-sifting arrangement, by means of which the fine ashes fall into the pail or tub, whilst the coarser parts fall on the fall below, and are ready for use again as a fuel. At the back of the closets is a movable wooden receptacle, where all the other house rubbish, such as vegetables, straw, house sweepings, etc., are thrown. Slop waters pass through a grid into the sewers. There is thus a complete division and separation of the three classes of material, and, practically, there is found no difficulty in maintaining this arrangement. The fine ashes, falling into the pail, sink to the bottom, carrying with them the fæces or solid matter. The pails and the excreta are collected regularly, at intervals not exceeding one week, and oftener when possible. A specially constructed van for this purpose carries empty pails, to be substituted for the full ones. A close-fitting lid, which hermetically seals the pail, is attached to the full pail, which is then transferred to the cart, and the clean pail placed in its stead. At the back of the van is a division, into which the house refuse is emptied from the box, which is then replaced empty, the door inclosing the whole being locked up until the operation is repeated the following week. The removal is thus effected almost without any nuisance either to sight or smell, the ashes acting as a deodorant. On arriving at the yard, the pails are emptied into vessels, and the contents treated with sulphuric acid, or sulphate of lime is added, with a view of fixing the ammonia. The urine mixed with a small quantity of fæcal matter is, by means of strainers, separated from the solid portions, consisting of excrementitious matter mixed with fine ashes, and is pumped into tanks, whence it runs in a small stream through a pipe into the "concretor," for the purpose of being evaporated at a low temperature, so as to reduce its bulk. The solid portion is taken into what is termed a "concentrator." The concentrator is thus described by Mr. Whiley, the superintendent of the yard, in a paper read before the Manchester Scientific and Mechanical Society:—"The apparatus consists of a jacketed cylinder, fixed horizontally, with a hollow spindle running through its centre, to which are affixed a number of hollow arms, both spindle and arms being heated with steam. When the spindle is put into motion, the heated arms come into contact with the material with which the machine has been filled, and dash it against the heated surface of the cylinder. This action disintegrates the material, and deprives it of its moisture by evaporation, whilst a fan connected with the machine draws out the vapor as rapidly as it is generated." The apparatus, it is said, will concentrate or reduce 3 tons 12 cwt. of excrementitious matter and ashes to 24 cwt. in two hours (including filling and emptying). From the same source the following description of the "concretor," the invention of Mr. Alfred Fryer, is taken: "This machine consists of a plated iron cylinder, with openings at each end, rather smaller than its own diameter. It is placed with its axis horizontal, and its interior is fitted with between two and three thousand superficial feet of metallic plates, arranged in spirals, extending from the centre to the sides. When the liquid is introduced to the interior of this cylinder, and the latter is caused to revolve upon its own axis, not only does its inner surface become wetted, but the extended area of the spiral blades become moistened on each surface. Heated gases are then drawn rapidly through the cylinder, and as they pass over the wetted surfaces they absorb the moisture, and thus effect a very rapid evaporation, the liquid remaining comparatively cool, no matter how highly heated the gases may be. The urine is admitted at one end of the cylinder and emerges from the opposite end; and so rapid is the process that a very few minutes elapse before the liquid emerges from the other end, of about the same consistency as treacle, above 90 per cent. of the liquid having been dissipated in the form of vapor. The gases enter the cylinder at a temperature of 600° F., or even a greater heat; but the urine in concentration never reaches the temperature of 130° F., and is generally even cooler than that. At so low a temperature there is no loss of ammonia whatever; indeed, the very slight decomposition of the urea adds its ammonia to the stock. The source of the hot air supplied to this apparatus is derived from the combustion of cinders, etc., and the small portion of sulphurous acid present in it is seized by the liquid, and effectually fixes the small proportion of volatile alkali." The urine thus reduced is mixed with the finer portions of the material from the concentrator, and forms, with animal matter and refuse from the butchers' yards, tripe-dressers, and other animal matter ground up with it, a manure which is sold at the yard at 12s. 6d. per ton. It is readily purchased by the farmers as fast as it can be made.

The street-sweepings are not at present dealt with; but a considerable quantity of the unsoiled midden stuff from the old middens yet remaining is got rid of by heating it to redness in a furnace and then converting it into mortar. A portion of the midden stuff that is unsoiled by fæcal matter is carted to the tip. The soiled midden stuff is put at once into boats and taken off to a farm in the country, bordering the Irwell, on which the Health Committee have a wharf.

The dry rubbish is sorted and screened, and such parts as are capable of being burnt are made into charcoal, in carbonizers, and this is used for mixing with the manure; other parts, such as the meat tins, are sold at 10s. a ton to the makers of an iron salt, whilst the broken crockery, bricks, clinkers from the furnaces, etc., are ground with lime into a mortar, which sells readily at 4s. 6d. a ton. About 300 tons per week are thus manufactured. A steam-engine of 40-horse power works the machinery in the yard, and is fed entirely with the ashes and rubbish fuel collected; not a single pound of coal is purchased. The Corporation have another yard where the closets, pails, etc., are constructed and repaired. The machinery for this purpose is driven by a steam engine, the fuel for which is entirely supplied in like manner, no coal being purchased. By the means thus employed, the whole of the material collected by the vans from the houses on the pail system is either destroyed or converted into a salable material, and this is effected with little or no offensive smell. The yard, when I visited it—and everything was in full operation—was clean and free from disagreeable odor. The following will give some idea of the nature of the weekly collection made:

	Tons.
Paper	1
Dead animals (dogs, cats, etc.)	2
Rags	3
Stable manure (from their own stables)	17
Meat tins, old tin, and iron	33
Slaughter-house refuse	60
Broken pots, bottles, glasses, etc	80
Vegetable refuse (such as floor mats, table covers, old straw mats and mattresses)	90
Fæcal matter and fine ashes	1,200
Cinders	1,344

Nothing is at present being done to purify the Irwell from the filthy contents of the sewers, or to utilize them in any way. This is considered secondary to this pail system, and will be attacked when the latter is complete. It must be borne in mind that, by the complete adoption of the pail system and the abolition of middens and cesspits, the sewers are relieved of a considerable amount of noxious matter that now flows into the river. So that when the water-carried system is attacked later on, as it necessarily will have to be, the evil to be dealt with will be, *pro tanto*, diminished.

At Salford, which I visited, I found that the Corporation there were perpetuating an improved midden system, compelling all to be covered in, though in some instances they were getting Morrell's Automatic Cinder-sifting Closet into use, but the cost (£12) for conversion was operating as a strong check to their introduction.

Birmingham, with its suburbs, has about the same population as Manchester; has 7,514 water-closets and 16,000 pail closets, and 8,870 ash-tubs, 27,426 privies in connection with 19,154 ash-pits. The pails here collect the fæces and urine together, but no ashes are mixed with them. The contents of the pails are collected in vans similar to those of Manchester, and the night soil and ashes in the ordinary carts. The whole is brought together in yards, at several wharves in the town; where all is mixed, pail stuff and ashes, and loaded into barges. The mixture is conveyed to farmers, who take it, paying about 4s. 6d. a ton. The Health Committee of the town have decided to adopt the Manchester system, and are now constructing the necessary furnaces and apparatus for that purpose.

The water-carried sewage is taken to the outskirts of the town, where it is treated with lime, let into a series of admirably arranged settling tanks on a very large scale, and, after precipitation, a tolerable effluent is obtained, which flows into the small stream in the neighborhood of the works. The immense mass of sludge which is thus deposited forms a great difficulty. At present it has to be dug into the land, which lies contiguous to the works, and the cost of so doing amounts, as I was informed, to £14 per acre.

Whilst at Birmingham, I had an opportunity of seeing the works which have been for some months past, and are still, in operation for demonstrating the efficacy of General Scott's system of dealing with dry sewage or pail stuff. General Scott takes the contents of the pails, which, it will be remembered, are free from any mixture of ashes or other refuse, roughly strains off the grosser solid matters, and runs the liquids into a boiler, where they are mixed with a suffi-

cient quantity of calcined dolomite to furnish a base for combination with the carbonic acid holding the ammonia in the urine, etc. The mixture is then boiled, and the united action of the alkali and the heat sets free the ammonia, which is distilled over into sulphuric acid, and fixed as ammonic sulphate. When the process has been carried far enough to drive off three fourths of the ammonia, sufficient superphosphate of lime is introduced into the boiler to neutralize the magnesia of the dolomite. The result is the formation of a magnesic phosphate, to which in the act of formation the greater part of the remaining ammonia in the liquid flies, forming the well known double salt, the ammonio-magnesic phosphate, which precipitates, it being fairly insoluble; the compound is then turned out of the boiler, and filtered in a Needham and Kite press. The liquid filters away, and may, if necessary, be treated for the extraction of the soluble phosphoric acid, but it has very little ammonia left in it. The solid cakes from the filter press are then ground up with the solids, which were strained off from the pail stuff. The grinding is done in an edge runner, and the mixture is subsequently dried on hot plates. To this dry manure as much of the crystals of ammonic sulphate are finally added as needed, and thoroughly amalgamated in a disintegrator. A highly concentrated manure can thus be formed. Only from two to three tons per week of this manure can be made by the present apparatus at Birmingham. About four tons of pail stuff are treated at a time, the works having been erected on a small scale, and solely for the purpose of demonstrating the efficiency and cost of the process.

The manure thus made is stated to be salable at about £6 10s. per ton, the value of course depending on the amount of ammonia and phosphate mixed in the manner mentioned above. The cost of producing this manure is stated to be not more than two-thirds of its selling price.

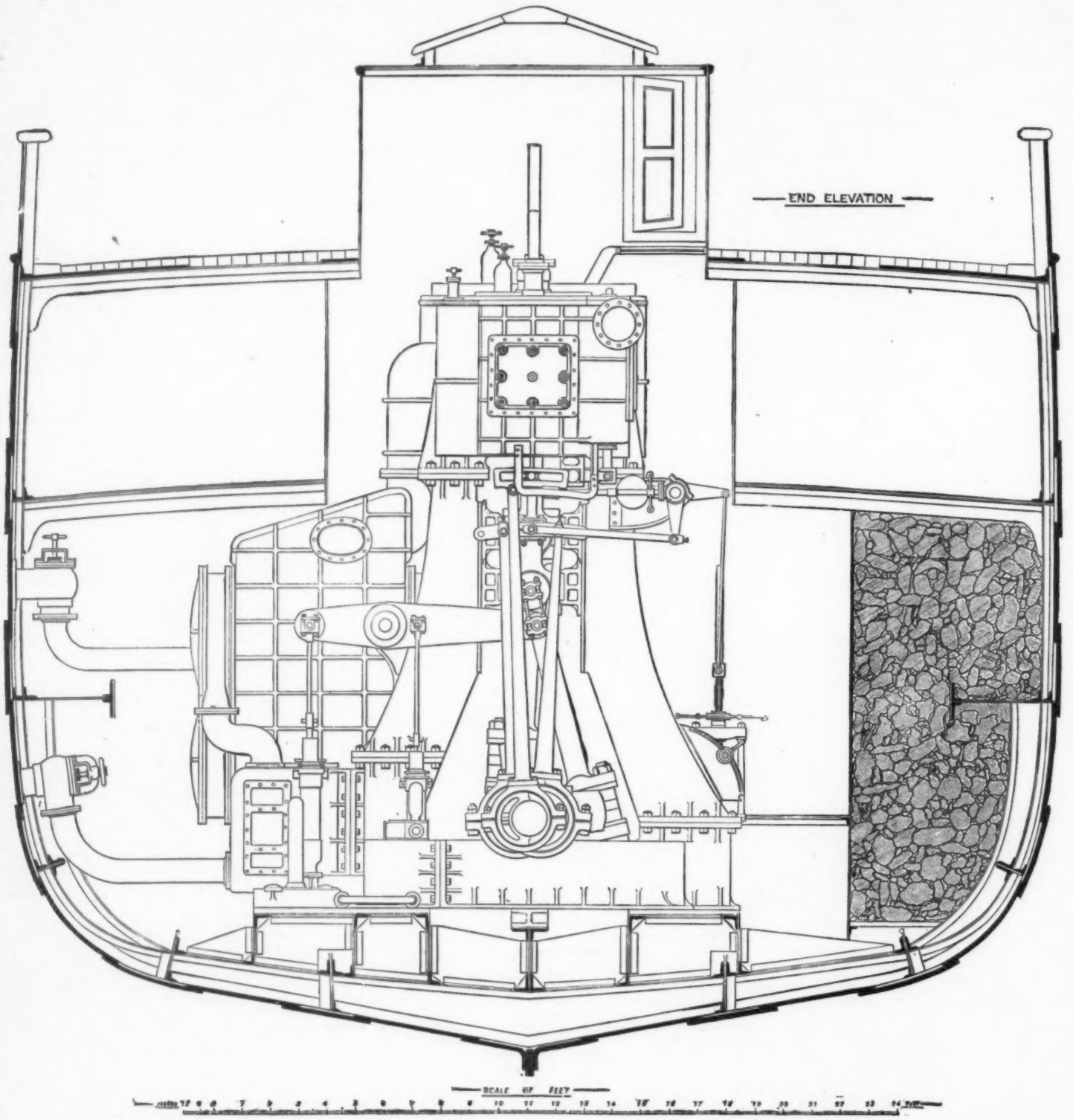
HYDRAULIC TOOLS.

AT a recent meeting of the Society of Engineers, London—Mr. Thomas Cargill, C.E., President in the chair—a paper was read by Mr. Ralph H. Tweddell on "Direct-acting Hydraulic Machinery." The author first described the case in which gearing by shafting, wheels and belts were used for driving machinery. He then alluded to the advantages of that mode of transmission, especially in large workshops where the machines were placed far apart. After considering the transmission of power by steam for driving small engines on each machine, he proceeded to describe his application of hydraulic pressure to the transmission of the power, and also to working the tools themselves. To illustrate this part of the subject, he described the differential accumulator, by the special construction of which the effect of a blow is obtained, as well as a steady pressure; and referred to the success which has attended the adoption of his hydraulic riveters to this combination. After giving some data as to the working of the portable riveter, one of which can close 5,000 ⅞ inch rivets in 9¼ hours, he described the hydraulic plant at the Toulon Dockyard, where the principal machine shop, 380 feet by 170 feet, is fitted up entirely on his system. Confining his advocacy of hydraulic power to special applitions, he claimed that, for certain stated purposes, as compared with gearing, it was cheaper because it effected a saving in cost of buildings; safer, in that there was no shifting of belts; more economical, because pipes never got out of order, while shafting always required attention; more efficient, because the friction, etc., in shafting, increased the wear and tear; and also, because with shafting, to work the smallest machine in a shop, it was necessary to drive all the shafting, whereas with water it was not so. Comparing hydraulic with steam power, he showed that, owing to the limited pressure obtainable by the latter, it could never compete with water at 1,500 or 2,000 lbs. per square inch even for fixed tools, and that for portable machines it was totally inapplicable.

THE first and only railway in China, the line from Shanghai to Woosung, recently built by English capitalists turns out to be a great success.

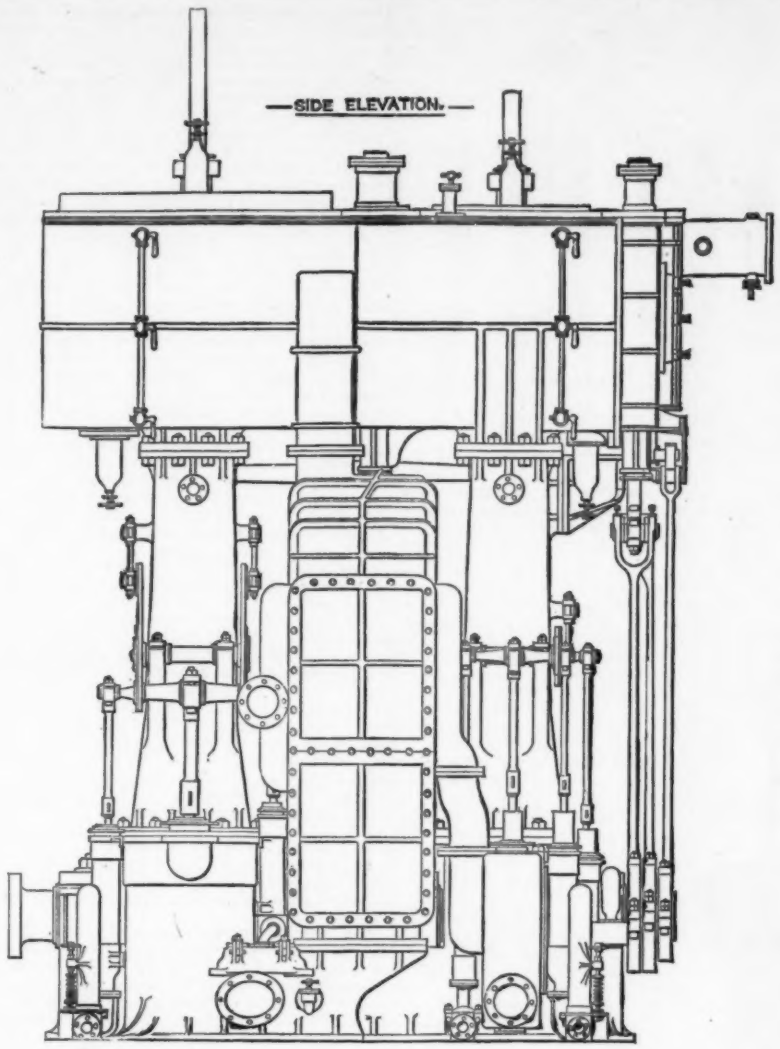
ENGINES OF THE STEAMER LOUDOUN CASTLE.

OUR engravings illustrate the engines of the steamship Loudoun Castle. This ship was built and engined last year by Messrs. James and George Thomson, Clyde Bank Foundry, Glasgow, for Messrs. Thomas Skinner and Co.'s "Castle" line of steamers plying betwen London and China. On her trial trip she made 13¼ knots with 2,400 indicated horse-power, neither boilers nor engines giving the slightest trouble. She made her last run from London to Shanghai in thirty-six days nineteen hours, being, we believe, the quickest passage on record. The average power was 2,200, and the total consumption of coal, divided by this and the number of hours, gives 1·87 lb. per indicated horse-power per hour.



ENGINES OF THE STEAMER LOUDOUN CASTLE.

The dimensions of the Loudoun Castle are—length, 350 ft.; breadth, 36 ft. 8 in., depth, 26 ft.; gross registered tonnage, 2,472. The engines are on compound, surface condensing principle, cylinders 48 in. and 85 in. diameter, and 4 ft. stroke of piston. They are jacketed with steam on the sides and covers, and the piston-rods are continued up through the latter. The main slide valves are double-ported, have balance pistons, and are relieved of back pressure; they are worked by link motion of special design, and have steam and hand-starting gear. The boilers are five in number, all supplied with stop-valves so constructed that they cannot be fixed to their seats, and are opened by the steam pressure from the



ENGINES OF THE STEAMER LOUDOUN CASTLE.

boiler, thereby entirely obviating one risk of explosion. The cubic capacity of the boilers is 6,774 ft.; total fire-grate surface, 280 square feet; tube surface, 5,908 ft.; total heating surface, 7,200 square feet; an annular superheater of 322 cubic feet capacity and 172 square feet heating surface is also supplied.—*Engineer.*

HINTS TO YOUNG MACHINE-TENDERS.

By AN OLD PAPER-MAKER.

THE following suggestions are made for the benefit of young machine-tenders, who are frequently "put to it" to meet an emergency:

Putting on a Wire and Running It.—When the wire is on, and all the rolls in, turn it around two or three times; then put on your top coucher and your stretch-roll; tighten the wire down according to your own judgment, having a sharp lookout for the seam. If it should commence running ahead on either side, it should be fetched back by tightening the side that is running ahead. If the wire will not guide right, that is, if it will insist on running to the back side, shift the top coucher back nearest to the breast roll on the front side one eighth of an inch. The same if it should run to the front side. Always keep the seam of the wire straight. If you do not it will wrinkle. Every time a new wire is put on, a new under-jacket should always be put on.

A little leading off will be required just here, keeping your eye well open, and your hands out of your pockets.

How to Clean a Wire.—Raise the "doctor" on the coucher a very little, get two pails of vitriol and water; pour the fluid on the coucher. Before doing this, stop all the water off the wire. Then take a brush and brush it all over on the suction box; then clean it well with water. After this process the machine should be started up right away, if not, it will be likely to injure the wire. When you are making strong-sized paper the edges of the wire should be cleaned once a day with hot water and brush.

How to Clean a Dandy.—Brush it well with vitriol and water; take some soda ash; dissolve it in hot water, and pour it on the dandy; then scour it well with water.

How to Make Good Edges.—Keep the deckles one eighth of an inch clear of the slices and fender; when the machine is running, keep the wire tight, and set the deckles in a little nearer the coucher, and keep the deckle frame a quarter of an inch away from the strap.

To Make a Good Sheet of Paper.—The roll under the dandy should be kept half or three quarters of an inch from being perpendicular under the dandy. This will form a good sheet of paper and keep it from sticking to the dandy. In making "laid" the roll should be brought more under the dandy, and use your first suction according to the stuff. The water should drop evenly from the roll under the dandy, all across; if not it will show you are making your paper uneven.

To Keep Paper from Worming.—Tighten the wire a little; bring the top coucher back half an inch; take the guide as much nearer the top coucher as it will allow; keep the doctor well down on the coucher; suck it as dry as you can with the last box. In putting on new jackets turn the bottom one inside out. If that doesn't stop it worming, serve the top one the same. Slack the weights up on the top coucher and keep both of your jackets clean.

To Stop Crushing.—Tighten the wire; bring the top coucher back half an inch; slack up the weights a little, suck as dry as possible and keep the doctor well down on the coucher; take the guide a little nearer the couchers, keeping both couchers clean. The couchers should have two rows of holes bored in them to keep the paper from worming or crushing. These holes should be one foot apart and three-sixteenths of an inch large. As soon as you shut down, at any time, *always* clean the top coucher.

To Stop Blowing in Front of the First Press.—Put more weight on the press; slack the weight on the coucher; tighten up the felt a little; run a little slower; raise the roll in front of the press; run a roll on the felt about two inches from the first felt roll.

To Stop Crimping on Thick Paper.—The wire at all times should run a little slower than the first felt on thick paper. A roll on the felt will help it; if that does not stop it, the wire is still running too fast. Raise the roll in front of the first press.

To Prevent Sticking.—To stop paper from sticking to the press, slack up the weights on the press, put a little more weight on the coucher, and keep the felt clean. In putting on a felt see that the nap always lies smooth when the machine is running.

How to Stretch a Jacket.—Put it in a pail of hot water for a few minutes; then put it on your stretcher, and stretch it two or three inches larger than the roll. When it is on secure one end; then stretch it as tight as you can get it, without using any water. After both ends are well secured put the man-heads on, and pour on hot water.

Notes by the Way.—Put it in a pail of hot water for a few minutes; then put it on your stretcher, and stretch it two or three inches larger than the roll. When it is on secure one end; then stretch it as tight as you can get it, without using any water. After both ends are well secured put the man-heads on, and pour on hot water.

Notes by the Way.—If the paper looks cockley on the sides and don't dry smoothly, tighten up the dryer felt. When the paper is too dry it will look cockley as it leaves the last dryer; when wet it will look smooth and steam. If the paper breaks down more than once or twice, follow the end up and see what is doing it. If it is a felt mark it will look crushed. If the seam is stopped up, or if there is a crack in the wire, or if there are drops from the deckles, or spots in the wire, or ragged edges, all of these will break the paper down. The ends of your coucher should also be kept clean. If they are not, the paper will break down at the calenders and run up on the first press. If the jackets get too bare and will not couch, bind some very thin flannel around the ends, five inches wide and lap six inches. If a dent should get in the wire tighten it up a little, and wash the top and bottom coucher where the dent is, easing the weights a little, and suck as dry as possible with the last box.

The apron should be one and a half inches from the first slice. The first slice should be quite level; the second one should be a little rounding on the ends in order to make good edges. When making strong-sized paper, the edges of the wire should be cleaned once a day with hot water and brush.

To make a fan-pump work well it should draw the water into it regularly. If it does not it will suck air. This is often caused by the hole that lets the water into the fan-pump being too large. This being the case, a gate should be put inside of the box, so that you can slide it up or down. This will make the pump throw much more regularly.

To find out spots in the wire take a sheet of white paper and hold it under the wire.

The machine running too fast or too slow will make the dog on the cutter work badly.

To make more "shaving," tighten up the dryer felt a little.

To make slitters work well they should be three-sixteenths of an inch deep in gear. The top slitter should be half an inch from being perpendicular with the bottom one. Let the slitters be worked all one way, the top slitter to go nearest the cutter. If you see little bladders behind the coucher they will indicate that it is worming.

How to Make a Suction Box.—The wood should be mahogany, made out of inch and a quarter stuff. The box should be four inches deep inside. The groove to the center should be an inch and a quarter, the pipe the same size. Take the pipe down some six or eight feet; give it a slight curve one foot from the bottom. The idea of running the pipe into a tub of water is all nonsense.

To keep the first felt open and clear there should be angle rolls under the felt two inches and a half in diameter, and six inches angle from the center on a 72 in. machine. The spindle in the center should be five-eighths, the outside an inch and a quarter.

To prevent a felt from wrinkling both ways, keep the blue mark in the felt straight. If it runs ahead in the center it will wrinkle both ways. That is caused by the roll swelling in the center. The rolls always being dry at the end causes this. To stop this, bind around two or three of the rolls a piece of calico or thin canvas eight inches wide on each side. This

is much better than worms, and keeps the felt open, and it will run steadier.

To prevent a felt from cutting on the edges, keep them wet. For a straight wrinkle in a felt, the pieces of calico around the rolls will fetch them out.

If the blue mark runs ahead too much in the center, have the rolls taken out and turned over afresh. A shaving more should be taken off the middle of the roll than at the outsides.

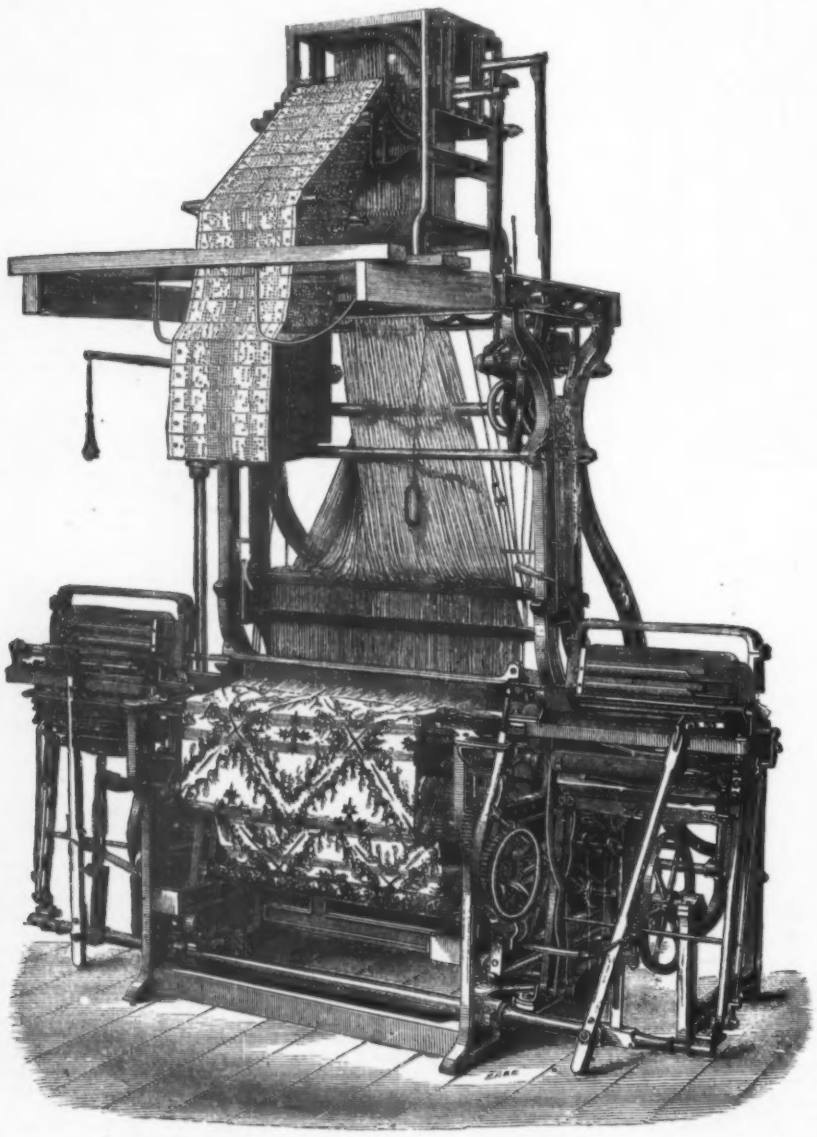
To take a wrinkle out of a felt tighten up the side that is running ahead about half an inch. If it commences running to the other side slack it up a little, and then tighten up the felt a little. If the short felt is too slack it will wrinkle. Always keep this felt tight.

The side that looks the slackest is the tightest, and the blue mark is behind. Look after the blue mark. The side that is running ahead must be fetched back by tightening it up a little, or by slackening up the other end. If your felt is in a very bad wrinkle before you notice it, at once take the weights off and throw the press out. To keep either the first or second felt clean and also to prevent it from cutting on the edges, keep the roll in front of the press as close as you can. The first press felt roll should be five inches from the level of the bottom press-roll; the second, three inches.

In all these arrangements the leading off should be done according to your own judgment.—*Paper Trade Journal.*

THE GATES CARPET POWER-LOOM.

CARPET weaving is an industry which is always approaching perfection, and the machinery of which is continually undergoing modifications and improvements. The cumbrous



THE GATES CARPET POWER-LOOM.

and slow wooden hand-looms of former days were succeeded by iron machines working by power, and at much greater speed, and the power-looms of the present day are many of them as much in advance of the first of their types as the most rapid sewing machine of to-day is in advance of the earliest working mechanism of its kind.

The carpet power-loom, which may be said to have been brought to the most comparative completeness and perfection next to the Brussels and tapestry power-looms, is that for producing the original Kidderminster carpet, commonly called in the North of England "Scotch carpet." This description of carpet is now chiefly made in Yorkshire, Durham, and Scotland, but with few exceptions, on the old-hand principle. It is a two-faced carpet, the warp which is worsted usually being of two colors, one representing the ground and the other the figure or pattern, while the various shadings of color which are so characteristic of this kind of carpet obtained by the weft are composed of woollen and in lower qualities sometimes of costly cotton.

The advantages of a power-loom are chiefly as a rule speed and firmness of work, as will be seen a little further on with reference to Scotch or Kidderminster carpet, the speed obtained by power is nearly four times as great as can be obtained by hand-loom weaving. Against this must be set with many power-looms the necessity of using much stronger and more material, that "breaking down" may be guarded against.

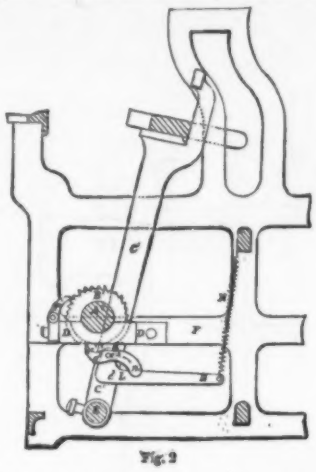


Fig. 2

We desire now to draw the attention of our readers to a loom that unites speed with, in a great degree, the capability of using the old qualities of yarns, and it is not surprising to learn that this machine is of American origin, for, from the States, where they manage the patent laws far better than we do here, have come many of our most useful and beneficial inventions. The excellent loom in question was, we believe, invented by Mr. Josiah Gates for the manufacture of Scotch and Dutch carpets, and the loom itself is now being constructed by Messrs. Edmund Leach & Sons, of Rochdale.

To manufacturers, whose space is limited, there would be considerable advantage in adopting this loom, if it were only because it requires but a comparatively small amount of floor space. As we have stated, the weft employed is of various shades, and, therefore, one very important feature in the Gates loom is the adoption of a revolving shuttle-box, admitting as many as sixteen different shuttles, each holding a different shade of color. This part of the invention being now complete, the greatest difficulty experienced in connection with a Kidderminster carpet weaving power-loom has been overcome, and we have little doubt that ere long all enterprising manufacturers will find it to their advantage to discard the old slow hand-loom process of manufacture, and will avail themselves of the quicker motion, for the capability of the Gates carpet loom is 25 to 35 yards of carpet per day, against 7 to 8 yards by the old hand-loom.

Another important feature in this loom is the double beat lay produced by a cam motion, by which means the threads of the warp in crossing are rendered perfectly clear of each other previous to the passage of the shuttle, which, with a single beat lay, would be far more liable to break the threads referred to. It is also to be specially noted that by this loom a firmer and closer texture of fabric is given than can be obtained by hand-loom weaving. Manufacturers will know how to appreciate this, as they are fully aware that buyers think much of the "handle" or "grip" of the goods, and look carefully to this before purchasing.

The take-up motion in this loom is also specially designed to supersede anything of the kind that has been produced before, and, compared with any similar motion, the great point gained is the excellent regulation of the tension, which is exactly suited to the draught and strength of the material, this material being very tender compared to the strong linen of cotton warp usually employed in Brussels and tapestry power-looms.

In connection with the shuttle motion, we should mention the improved bobbin catch by which the momentum of the bobbin is allowed to be gradually taken up by the action of a longitudinal spring. When the shuttle is set in sudden motion by a blow, the bobbin in this case first compresses the spring, and thus more gradually acquires its velocity, thereby saving a considerably portion of the "filling," which in an ordinary bobbin is either separated or loosened. The same gradual stoppage of the bobbin by a spring cushion takes place when the shuttle is driven home, and many "filling" bobbins are thereby saved, which in an ordinary shuttle are split by the sudden stoppage of the shuttle.

Fig. 3 is an underside view, and Fig. 4 a longitudinal section of the rear end of a weaver's shuttle, with the spring recoil above referred to. A is the bobbin catch, constructed with a longitudinal slot, band, a rising rear end, d^3, and furnished with a spiral spring, E, and a retaining pin, f^2, whilst the shuttle is supplied near the forward end of the bobbin-catch mortise with a stop or bar, e^4, as a bearing for the forward end of the spring.

The usual fulcrum pin, e^5, passes through the slot, b, and this allows the bobbin-catch and the bobbin to move forward, or to yield to the action of the blow of the shuttle when its forward end strikes. The spring E^1, instantly returns the bobbin and catch, or draws them back after each blow of the forward end of the shuttle. The spring acts between the bar, e^4, secured to the substance of the shuttle, and the ear, d^3, rising from rear end of the bobbin catch-plate, whilst the pin, f^3, projecting forward from the ear, holds this end of the spring in position, not only when in action but also when the rear end of the bobbin catch is passed upward to release the catch end from the groove, g^4, in the head, B^3, of the bobbin.

The improved take-up apparatus is illustrated in detail as follows, Fig. 2:—A 2 represents the cloth roll, and it has a ratchet wheel, B, on one end, a little inside the sword C, rising from the rocker shaft, E, and arranged to work in the usual way. The cloth roll is shorter than the loom, and it is supported in bearings on an open bracket, D, projecting inward from the end frame, F, leaving room between the frame and the bracket for the oscillating sword and the ratchet wheel.

At the forward side of the loom, and hung to the bracket or other support, is a pawl, P, to hold the wheel against the draught or unwinding action of the cloth upon the roll. In practice the pawl, P^1, is in two parts, that is, a long and short pawl to catch and hold on the distance of half a tooth, one pawl catching ahead of the other and *vice versa*.

To the lower portion of the sword, C^1, a lever of a peculiar construction is pivoted at C^2, and a lug or arm, d^1, rises at right angles to the lever, and to this ear a counter-balance pawl, g^3, is hung near its center by any easy-working joint or a pivot, e^3. The outer end, n^1, being most weighty, holds the catch end, S^2, in contact with the teeth of the wheel, B^1. The arm, A, of the lever extends rearward, as shown, and a spring, K, is attached to its end and to some fixed object or part of the frame.

The backward and forward motions of the sword impart the same motions to the lever and the pawl, g^3, causing the latter to engage with the teeth of the wheel, and when the cloth is slackened by the introduction of "filling" in the web, and by the action of the let-off mechanism, the motion and power of the oscillating sword cause the connected pawl, g, to turn the wheel and the roll, and to wind up the cloth as fast as it is woven. The introduction of the tension springs, K, is here most valuable. At some occasions, during the weaving of the cloth and the winding, the rate of let-off may not exactly correspond to that of the winding on, and at the same time there is always a certain tension most suitable for the taking up of the cloth. When the forward motion of the "sword" brings the pawl into contact with the tooth of the wheel, the wheel may be either driven forward, or, if the resistance be great, the spring, K, will yield, and allow the end of the lever, H, to depress under the action of the rock of the "sword," instead of the ratchet wheel being driven by the pawl. The tension with which the cloth is wound up will thus depend upon the tension of the spring, and thus

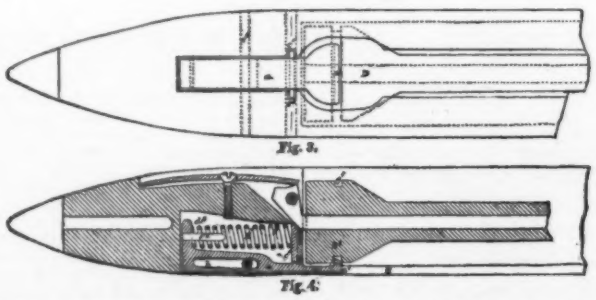


Fig. 3.

Fig. 4.

will remain tolerably regular, and may be adjusted to any required winding-up tension.

The Gates machine is supplied with a most perfect automatic gear, by means of which the action of the filling beat is at once checked and thrown out of action if the shuttle has not been fully returned home after its last traverse across the warp. In this way, should a shuttle be caught and not reach its box, the action of the lay is instantly suspended, and the shuttle replaced without any injury having been done to the warp.—*Textile Manufacturer.*

CUTTING OUT KEYWAYS.

By JOSHUA ROSE.

CUTTING out keyways has always been a difficult and expensive job, and even at the present day the method of operation in different shops varies widely. There has of late, however, been introduced into some of the manufactories in the Eastern States a method by which keyways can be cut out with great rapidity, and with a degree of accuracy that cannot be approached by ordinary hand labor. Before explaining this method, however, it will be well to note the modes of procedure which were formerly, and are still to some extent, employed.

The method which is used in shops having but ordinary lathes, planers, and drillers, and which is still followed in one of our largest locomotive shops, is as follows: The location of the keyway is marked off by lines on both sides of the stub end of the rod, and then the mass of the metal is removed by drilling through as many holes as can be got in

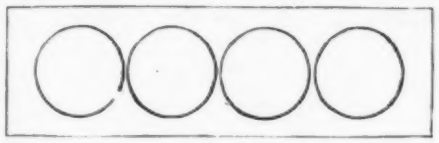
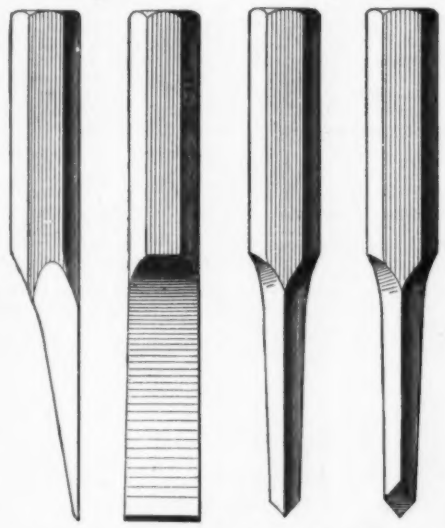


FIG. 3.

the size of keyway required, as shown in Fig. 3, taking care to have the drill rather smaller than the width of requisite keyway. The holes are drilled halfway through from each side, which is done to keep the keyway true; for if the drills were to run a little to one side, as they are apt to do from a variety of causes, a great deal of work would be required to correct the error.

If the keyway is of sufficient dimensions to admit of the use of a chisel, the pieces left between the drilled holes are chipped out, and for this purpose a side chisel, of the form

Fig. 1. *Fig. 2.*



shown in Fig. 1, is very useful not only to nick the sides of the pieces left by the drilling but also to take the finishing chipping cuts on the sides of the keyway. To cut out the square corners of the keyway, the diamond-point chisel, shown in Fig. 2, is employed.

If, however, the keyway is a very deep one, requiring long and slight chisels, the chipping process may be greatly reduced, or in fact entirely dispensed with, by plugging up the holes first drilled in the stub end by driving pieces of round iron tightly into them, and then drilling new holes, having their centers midway between the pieces so driven in. After the latter drilling, the remaining pieces of plugs are driven out, leaving the center of the keyway cut clear through and the sides with a series of flutes in them, as

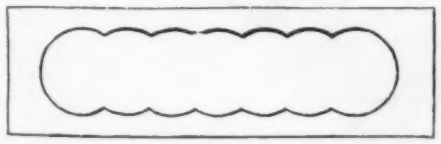


FIG. 4.

shown in Fig 4, which should be filed away with a file as thick or strong as the clear space will allow.

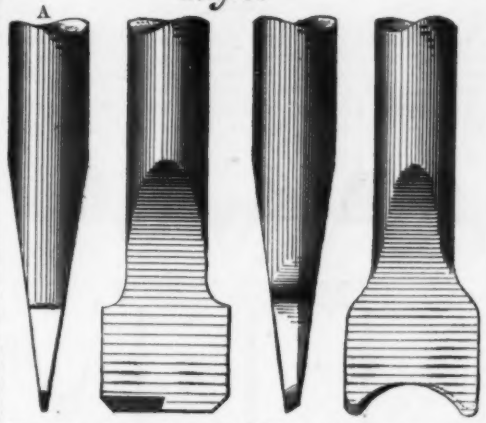
To insure truth in the surfaces, a surface plate to test with is an absolute necessity, while to test the parallelism, a small sheet iron gauge is used, which gauge may afterwards be employed as a guide whereby to plane the thickness of the gib and key.

In cases where a slotting machine is at hand, it is sometimes the practice to cut out one end of the keyway to a sufficient length to admit a slotting tool, and then to slot out the remainder. This plan is often resorted to in getting out keyways of unusually large dimensions.

A much more usual method, however, is to employ slotting or keyway drills, such as shown in Fig. 5.

In the use of these drills either the work or the drill must traverse, and many special and expensive machines have been designed for their special use. In some of these machines two drills lying horizontal (so as to drill the keyway halfway in from each side simultaneously) are used, while in others a single drill with a vertical spindle is employed. In

Fig. 5.



either case the work or the drill must traverse an amount equal to the length of the keyway. The drill, shown at A in Fig. 5, is the form in which this tool is largely employed in Europe, while the lower one represents the form generally preferred in the U. S. The former will take the heaviest cut and last the longest, but the latter will perform the truest work, for the reason that it is more steadied by its own cut; hence, if we use one of these drills to cut out a keyway halfway from each side, we shall find the junction of the two slots come more fair than if the form of drill shown in the first figure were used. It is obvious that the ends of the keyways cut by these drills are half round; hence, if square corners are required, they must be cut out square with the chisel shown in Fig. 2, and afterwards filed out true. As a general rule, keyways cut with these drills require filing on the sides to get proper smoothness and bearing for the keys, and here it may be remarked that, in filing in the corners of the keyway, a safe-edge file must be used, so that the two faces forming the corner will not be operated upon simultaneously, because that would require that the file be used in a straight line laterally as well as horizontally, and this is impracticable even in the hands of the most skillful.

Even the square file should have a safe-edge upon it, and such an edge is usually produced by grinding the teeth off one face of the file. In selecting the face to have the teeth ground off, choose a face that is hollow in its length, or, if none of the faces are hollow, then select a face that is at a right angle to a good face of the file. It will be noted that with one safe-edge only the square file will require turning over in order to operate upon both corners and maintain in each case a safe-edge of the file against the flat sides of the keyway. For this reason many workmen select the two best parallel faces of the file and grind off the two other faces, giving to the file two safe-edges, one opposite to the other. In this case either of the cutting faces of the file may be use upon the whole end face of the keyway operating close up to the corner, or if the file is much narrower than the keyway i may be used with a side sweep that will prevent the file from pinning, and produce much truer filing.

It is useless to attempt to cut out a square corner with a square file unless one edge of the latter is ground safe, because the teeth of the file itself do not form a square corner, and it is therefore only by grinding the teeth off one side that the points of the file teeth can be brought full up to a sharp angle. Here, however, it may be noted that even if the filing is performed with the best of safe-edged files, and as carefully as possible, it will still be necessary to square out the fine corners by using the edge of a fine smooth file.

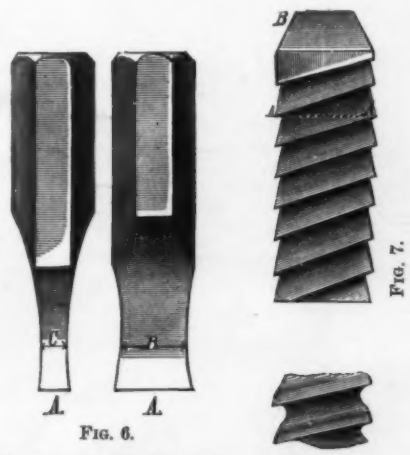


FIG. 6. FIG. 7.

Another way employed to finish small keyways is by the aid of the tools shown in Figs. 6 and 7, which are termed drifts, because they are driven through with a hand hammer. That shown in Fig. 6 is intended for holes having but little depth and not requiring to be very true, such, for instance, as those cut in the ends of keyways or bolts to receive cotters, the thickness at A A is made greater than at B C to give the cutting edge clearness.

The form shown in Fig. 7 was formerly used upon small and deep keyways, and it is an improvement upon the shape and method of using this tool which constitutes the most improved keyway-cutting practice of to-day. As formerly used, the keyway was chipped and filed out to very nearly the required dimension, and the drift was driven through to insure smoothness, evenness, and parallelism. There was, however, great skill required in its use, because if the work did not lie quite fair upon the block upon which it rested, if there was too much cut allowed, or if the face of the hammer did not strike the drift quite fair, the latter was almost sure to break. To avoid, as far as possible, this breakage, the teeth were cut diagonally upon the drift sloping in different directions on opposite faces, because, if the teeth on opposite sides were parallel one to the other, the drift would have a tendency to move to one side and crowd there during the process of driving. In entering the drift it was very apt to get aslant, and in that case very careful manipulation with the hammer was necessary to draw it straight

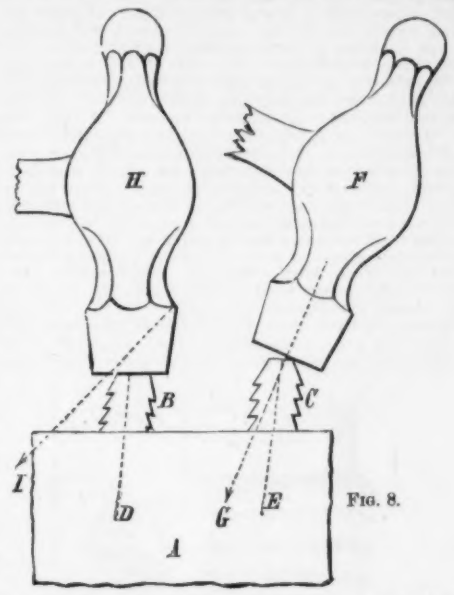
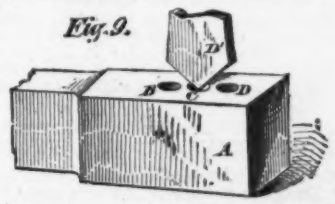


FIG. 8.

without breaking it. Suppose, for example, that, in Fig. 8, A is a piece of work and B C are two drifts entered in keyways, and out of straight, as denoted by the lines D and E. If then the blow delivered by the hammer F was in the direction denoted by the line G, and the face of the hammer did not meet the face of the drift fair, but at an angle, as shown in the illustration, the drift would in all probability break. Now, if we observe the hammer H, and suppose that the line I denotes the direction in which it traveled, we shall find that, though the direction of the blow is such as to tend in a greater degree to bring the drift B upright, still the face of the hammer and that of the drift are fair, and hence there would be much less liability to break the drift than in the former case.

The modern and most improved form and use of this tool, however, is as follows: If the keyway is to be cut out of solid metal, holes are drilled as closely together and as near the size of the width of the keyway as the circumstances will admit. After the holes are drilled, the metal remaining be-

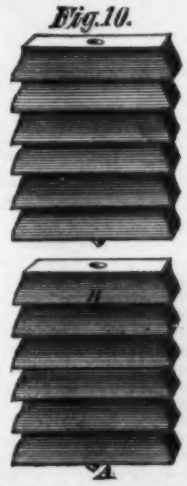
Fig. 9.



tween them is cut out, as shown in Fig. 9, in which A represents the stub end of a connecting rod with the three holes B, C, and D drilled in place for the keyway, and D the tool which is placed in a powerful vertical press and forced through the three holes, thus forcing outwards at one cut the two webs shown between the three holes, B, C, and D. The V-shape of the end of the cutting punch D^1 tends to steady it while in operation, forces the cut outwards into the next hole, preventing them from jambing, and causes the strain upon the punch to begin and end gradually, thus it prevents violent action during the ingress and egress of the cutting punch. This roughing-out process dispenses with the use of the hammer and chisel, and saves much time, since it is done at one stroke of the press. The next part of the process is the introduction of a series of what are known as broaches, being in fact drifts, such as shown in Fig. 7, modified so as to be forced instead of driven, the principles involved being as follows:

It is obvious that from the large amount of cutting edge possessed by a single tooth extending all around such a broach, it would be impracticable to take much of a cut at once, hence a succession of broaches are used, some of them

Fig. 10.



performing duty on the sides only, others at the ends only, but the last and final broach is usually made to take a very fine cut all over. All these broaches are made slightly taper, that is to say, the breadth of the lower tooth at A, in Fig. 10, is made less than that at B, the amount allowed varying in

different practice. For very fine work it is made about the one thousandth part of an inch only on the last cutter. The work is placed under a press, fastened in a suitable chuck, and the broach smallest in size is first inserted and forced through the keyway by the ram of the press until the top of the broach is about level with the top of the keyway. A broach of slightly larger dimensions is then placed in position—the method of adjusting the broaches so that they shall follow exactly in line being as follows: Upon the lower end of each broach is turned the center tit shown, and upon the top end is made a corresponding conical recess. By placing one broach upon the top of the other, then the tit and recess brings the two pair, one with the other, so far as keeping the center lines of the two broaches vertical. It follows, however, if the cutters are placed one on top of the other, that the top one might get atwist unless two center tits and corresponding recesses are used, as indeed they sometimes are. It is considered preferable, however, in placing the broaches, to let them meet the end of the press ram first, and so to form that as to make it adjust the top end of the broach true, so that all the operator has to do is to place the top end of the broach against the end of the ram, and hold the broach as nearly vertical as possible. Then, when it descends, the tit upon its lower end will readily adjust itself in the recess in the top of the cutter already in the keyway.

To accomplish this result, the end face of the press ram is provided with a recess, the edges of which are chamfered off and into which the top of the broach naturally glides when

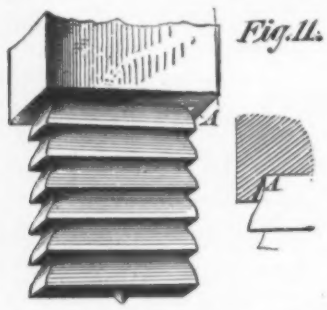


Fig. 11.

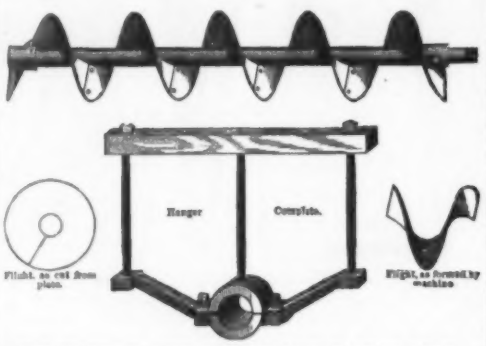
pressed upwards, and finds its true position, as shown in Fig. 11, in which A represents the end face of the ram shown in perspective and detail section, so as to exhibit the recess and the head of the broach fitting therein.

The depth of the broach teeth must be such as to provide ample room for the cuttings, while at the same time but very little clearance is required immediately behind the cutting edges, which will preserve both the size and the cutting qualities of the teeth. In proportion as the quantity of metal to be cut out to form the keyway increases more broaches must be used, and when the ends of the keyways are half round, or rather half-circles, the broaches are made to cut out the sides first and the ends afterwards, the broaches for cutting out the ends being left plain on the sides and made of a thickness to fit the keyway. The broaches are usually dipped into oil to wash out the cuttings, and are used with the oil dripping from them. They are tempered to a dark brown or purple, depending upon their size and strength, the slighter ones being left the softest.

CENTRAL ELEVATOR B, ST. LOUIS, MO.

ONE of the most noticeable things that presents itself to the gaze of European visitors in America is the existence in nearly all of our large cities of gigantic elevators for the storage of grain *in transitu* or previous to its being absorbed by the trade. The elevator may be said to be indigenous to American soil, and to form a distinctive feature in the American grain trade. The central location of St. Louis, in the very heart of the Mississippi Valley, has caused her to advance in importance with the States of which she forms the focus; and she is every year assuming a higher and higher position in the grain trade of the country. With the opening of the jetties, at the mouth of the Mississippi, her grain industry will undoubtedly attain enormous proportions. Our illustration shows one of the most notable elevators in the West, the one erected at St. Louis for the Iron Mountain Elevator Company.

This elevator is situated at the freight depot of the Iron Mountain Railroad, near the foot of Chouteau Avenue, and stands back from the Mississippi river a distance of 280 feet. The original intention and desire of the company was to erect the elevator at the water's edge; but the rights of the levee were so strictly guarded that they failed in this undertaking and were compelled to build the elevator at the distance named from the river. But virtually they have overcome the distance by means shown in our engraving. The object of this elevator is to form an outlet to the river for loading barges. On the completion of the jetties, the barge will play an important part in the grain trade of the West, as barges will be loaded with grain along the Mississippi and be towed to New Orleans, where the grain will be reloaded into large vessels for Liverpool, and other European ports, *via* the jetties. The enterprise in question was carried through by a resident of St. Louis, Mr. H. W. Caldwell, who placed one of his Patent Grain Conveyors on the



THE CONVEYOR.—CENTRAL ELEVATOR B, AT ST. LOUIS.

bridge, as shown in our illustration, and which now delivers 5,000 bushels of grain per hour into barges in the Mississippi river, a distance of 340 feet from the elevator. This conveyor is the longest continuous length ever put up. It demonstrated as true the theory and claim of the inventor, that he could run 5,000 bushels of grain per hour a distance of 1,000 feet.

The building is 150 feet long, 64 feet wide, and 96 feet high, and was built in 90 days. It has a storage capacity of 250,000 bushels, and contains 36 bins which are each 8 by 16 by 50 feet in size, besides 56 special car-lot bins. The building was christened "Central Elevator B," and it started into operation on July 4, 1876, duly constituted the only Centennial elevator in the country. It is under the immediate charge of N. G. & J. W. Larimore, well known in the grain circles of St. Louis.

The conveyor is made of wrought iron pipe on which is secured a flight made of wrought iron, steel, galvanized iron or copper, so cut and formed as to fit tightly around the shaft and stand at right angles to it. At the same time each flight makes more than a full revolution on the shaft, and the several flights being riveted together form a continuous and self-supporting conveyor flight. The flight is constructed on such geometrical principles, and the relation of diameter to circumference is so observed, that the greater the strain brought to bear against it, the closer it clings to the shaft. Although it is claimed to be impossible to crush the flight by fair means, its tenacity to the shaft is not entirely dependended upon to hold it in place, but it is secured in several ways. Flights made of galvanized iron or copper are fastened to galvanized pipe by solder. Iron or steel flights are secured either by riveting the angle knee to the flight and tapping the wall of the pipe and screwing a wooden screw into a wooden plug driven into the cavity of the pipe, or by riveting flat or button-headed nails to the flight and drilling through both walls of the pipe and riveting the flight on the opposite side, thus drawing it perfectly tight and smooth to the shaft. One great advantage claimed for the conveyor is that the shaft is small, and consequently the material is brought nearer to the center, while the friction is much less than in the ordinary wooden shaft. It is claimed that it will not sag or warp, and can be run so close to the bottom as to clean the trough. It is asserted that it is more perfect and durable in construction and requires less power to drive it than any other conveyors, and can be run at a higher rate of speed. It can be constructed so as to deliver as much as 10,000 bushels an hour, a distance of 1,000 feet; and can be used to perform work hitherto considered impossible for conveyors to do.—*American Miller.*

THE first submarine cable was that laid across the Straits of Dover, twenty-seven years ago.

PHOSPHOR-BRONZE AND ITS APPLICATIONS.*

By ALEXANDER DICK.

ACCORDING to antiquarian research, bronze formed the earliest alloy produced—some specimens are estimated to have an existence of from 4,000 to 5,000 years; it was not the alloy which we now call bronze, formed of copper and tin, but the result of the rough smelting of cupreous ores, and, of course, contained many impurities. It was used for casting domestic tools, weapons, and images; at a later period for bells, and still later for cannon. The difficulty of the bronze founder, during the later periods referred to, appeared to consist in the impossibility of obtaining pure copper and tin for his smelting, but even when these became articles of commerce, further difficulties were met with in producing sound and reliable castings, and it is of but a recent date that some light has been thrown on the nature and cause of these difficulties, as also on the way how to avoid or remedy them.

In the year 1868, Messrs. Montefiore & Künzel, of Liege, in Belgium, engaged in a series of very exhaustive experiments with bronze and bronze castings. These gentlemen observed that the tin in bronze continually decreases by oxidation during the process of smelting. They found that the oxide of tin partly goes into the slag and partly is dissolved in the molten metal.

	Tin.	Copper.
Bronze, originally composed of.....	10·10	+ 89·90
Contained after the first smelting.....	9·82	+ 90·18
" " second "	9·40	+ 90·60
" " third "	9·16	+ 90·84
" " fourth "	8·52	+ 91·48

The operators found great difficulty in determining analytically the proportions of the oxides, whether in combination with the tin or copper, or whether only mixed up in the metal; they found that "poling," a process by which the molten metal is stirred up with a wooden stick, will eliminate the oxide combined with copper, but has no influence on the oxide of tin; experiments by passing hydrogen over heated bronze filings proved equally ineffectual; the oxide combined with the copper was converted into water, and weighed as such, but the oxide of tin remained like in the "poling" process. It was in consequence of this difficulty that Dr. Künzel, for the first time, introduced phosphorus into the molten bronze; this had the desired effect, and the metal, which at first had a dull and covered appearance, all of a sudden became bright and of metallic surface. Thus, by introducing a small portion of phosphorus, or phosphuret of tin or copper, of previously ascertained composition, it was found that the total amount of oxygen contained in the molten metal could be ascertained analytically with perfect certainty. The absolute and elastic resistance of old bronze, that is, bronze containing oxides, is much smaller than that of bronze with new metal; and, as will be seen by the following experiment, "poling" will improve old bronze, whilst phosphorus greatly improves bronze "poled." Shavings of old bronze were melted and a bar thereof cast at 1595° C., the remaining liquid bronze was stirred with a wooden stick—"poled"—and a second bar cast at 1668° C. The then remaining metal was deoxidized with phosphorus and a bar cast at 1614° C. The three castings were thus made out of the same crucible and cast in the same manner in three moulds. The results were:

	Resistance, absolute lbs. per sq. in.	Resistance, elastic lbs. per sq. in.	Lengthening until rupture. Per cent.
Old bronze	22,983	17,020	2·0
" poled.....	24,922	17,709	2·8
" deoxidized with phosphorus.....	33,916	19,300	6·8

Thus, by the entire reduction—elimination of oxide—the old bronze has tripled its tenacity and considerably augmented its absolute resistance.

Having so far succeeded in eliminating the oxides from the bronze, the inventors showed that by the further addition of a small percentage of phosphorus to the bronze alloy the qualities of the latter became more and more changed, the grain or fracture became finer, the color brighter, the elasticity and resistance to strain and compression considerably increased, and when melted it attained great fluidity. Similarly, as minute quantities of carbon alter the physical properties of iron and convert the latter into steel, so a minute quantity of phosphorus changes those of bronze and converts the same into phosphor-bronze. It may thus be said in a certain sense that what steel is to iron, phosphor-bronze is to ordinary bronze.

* Society of Arts.

CENTRAL ELEVATOR B, AT ST. LOUIS, MO.

Messrs. Montefiore & Künzel next experimented with alloys of copper and nickel, and with manganese—binary alloys—also with—tenary—bronzes of copper, tin, and manganese, with copper, tin, and nickel, as well as with iron alloyed with copper and tin. The manganese alloys they concluded to be entirely useless, as also those of nickel and of iron. They obtained great tensile strength and hardness with some of these compositions, but their ready oxidability at high temperatures made the qualities of the castings uncertain and impracticable.

Sodium eliminated the oxides contained in the molten bronze, but the slightest surplus of it produced an alloy which could not resist the atmospheric influences, and oxidized with great rapidity. A minute addition of zinc to ordinary bronze augments the resistance to rupture by reducing involved oxides, but it softens the alloy and causes it to lose its elasticity. Phosphorus was therefore found to be the only ingredient which will improve bronze by giving reliable results. The action of phosphorus is twofold—(1) it eliminates the oxides as stated above, and (2) it makes the tin capable of adopting a crystalline structure—and, as two crystalline metals form a much more homogeneous alloy than two metals, of which one is not crystalline, phosphor-bronze must necessarily be more homogeneous than ordinary bronze. Homogeneity and absence of oxygen increase the elasticity and absolute resistance of the alloy. Another great advantage of phosphor-bronze is that its hardness can be regulated by varying the proportion of phosphorus, which, in ordinary bronze, is done by increasing the proportion of tin, whereby the danger of segregation in the casting is greatly augmented. Ordinary bronze, after one or two smeltings, becomes thick-flowing and putty-like, whilst phosphor-bronze remains perfectly liquid until the moment it sets—solidifies; if, therefore, it is cast just before the "setting" takes place, no segregation is possible. Combinations of phosphorus with copper, with tin, or with other metals, have long been known by chemists, but Dr. Künzel was the first to employ the same for the purposes above stated. A number of phosphor-bronze alloys are now manufactured, varying in composition to suit the objects for which they are intended. The scope of their application is of course very great. The harder alloys are used for casting bells, tools for gunpowder mills, etc.; other somewhat softer alloys are used for engineering purposes, and the still softer for rolling, drawing, and embossing, etc.

Cast metal.	Diminut'n of section before rupture.	Resistance in lbs. per square inch.	
		Elastic.	Absolute.
	Per cent.	lb.	lb.
Pure metal	3·30	4·400	6·975
Ordinary gun metal, containing nine parts copper, one part tin.	3·60	12·800	16·650
Phosphor-bronze.	8·40	23·800	52·625
"	1·50	24·700	46·100
"	33·40	16·100	44·448

The above table and the one that follows show the results of tests made by Mr. Kirkaldy, of Southwark street, with various phosphor-bronze alloys:

	Drawn metal.	Pulling stress per sq. in.		Twists in 5 in.		Ultimate extension.
		Wire as drawn.	Annealed.	Wire as drawn.	Annealed.	
		lb.	lb.	lb.	lb.	Per ct.
Various alloys.	Phosphor-bronze	102·759	49·351	6·7	89	37·5
	"	120·957	47·787	22·3	52	34·1
	"	120·950	53·381	13·0	124	42·4
	"	139·141	54·111	17·3	53	44·9
	"	159·515	58·853	13·3	66	46·6
	"	151·119	64·569	15·8	60	42·8
Copper		63·122	37·002	86·7	96	34·1
Steel		120·976	74·637	22·4	79	10·9
Iron, galvanized best charcoal E		65·834	46·160	48·0	87	28·0

A series of interesting experiments with phosphor-bronze were made in Berlin by the Royal Academy of Industry, in order to ascertain the qualities and capacities of the metal whilst under heavy strain, and its resistance to often-repeated strains. The first bar of phosphor-bronze was tried under a constant strain of 10 tons per square inch, and resisted 408,230 pulls; a bar of ordinary bronze broke even before the strain of 10 tons per square inch had been attained. A second bar of phosphor-bronze was tried under a strain of 12½ tons per square inch, and withstood 147,850 pulls, and a third bar, under 7½ tons strain, broke only after 3,100,000 pulls. On the bending machine, phosphor-bronze, whilst under 9 tons strain per square inch, remained unbroken after 4,000,000 bends, whilst ordinary bronze broke after 150,000 bends. Major Majendie tested phosphor-bronze as to its liability to emit sparks when subject to friction, and attained very satisfactory results. The experiments were carried out at the Royal Gunpowder Works at Waltham Abbey. A grindstone of 9 in. diameter was made to revolve very rapidly, so that any point on the grinding face would describe a distance of 2,000 ft. per minute; the metal was then pressed against the revolving stone, and the results proved that the harder descriptions of phosphor-bronze emit sparks less readily than the softer samples, and much less readily than ordinary gun metal or copper.

For frictional purposes the Phosphor-Bronze Company, in London, produces a special alloy, by fusing phosphor-bronze in certain proportions, together with another soft alloy of different degree of fusibility, so as to produce by cooling the given alloys. The shell is then formed of a very tough and hard phosphor-bronze, and the interior of aforesaid soft alloy. The bearing surface may then be considered to consist of a large number of small bearings of soft metal, inclosed in castings of metal almost as hard as the arbor itself. The microscope reveals this disposition very plainly, and if one of these bearings be carefully submitted to heat, so as to cause the soft fusible metal to run off, the rest will remain in the form of a spongy mass. Bearings, slides, eccentrics, etc., of this peculiar alloy are now very largely in use, and the practical results show that it wears more than five times as long as gun metal.

Phosphor-bronze is readily rolled or beaten out into sheets. In Russia it has been used as a material for cartridge sheathing, and specimens have stood 120 trials without tearing. Sheets of the alloy stand the action of sea water much better than copper. In a comparative experiment made at Blakenbergh, lasting over a period of six months, between the best English copper and phosphor-bronze, the following results were arrived at:

Thickness of the sheets =0·236 in.	Weight before immersion.	Weight after immersion.	Loss of Weight.	
	lb.	lb.	lb.	Per cent.
Sheet of copper	74·4	72·2	2 2	3·015
" "	88·9	86·2	2·7	3·100
Sheet of phosphor-bronze.	69·5	68·75	0·75	1·123
Sheet of phosphor-bronze.	114 3	112·97	1·33	1·195

The loss in weight, therefore, due to the oxidizing action of sea water during the six months' trial, averaged for the English copper 3·058 per cent., while that of the phosphor-bronze was but 1·158 per cent. or about one-third. Several governments have experimented on the use of the alloy for making cannon. Without any exception, the results showed a much greater resisting power over that possessed by ordinary bronze. The following instances of the results arrived at will be of general interest.

In Belgium the ordinary bronze gun burst at the second shot, with a charge of 1 k. 250 gr. (2¾ lbs.) of powder, and a cylindrical projectile weighing 8 k. 518 gr. (18¾ lbs.). The phosphor-bronze gun supported this charge perfectly; the normal charge was 500 gr. (1 1/10th lbs.) of powder, and 3 k. (6¾ lbs.) of projectile.

In France the ordinary bronze gun burst at the second shot, with a charge of 1 k. 500 gr. (3¼ lbs.) of powder, and 16 k. (35½ lbs.) of projectile, while the phosphor-bronze gun was fired five times with this charge, and burst at the second shot with 1 k. 750 gr. (3⅞ lbs.) of powder, and a projectile of 20 kil. (44 lbs.) owing to the weighing of this in the barrel. The normal charge was 0 kil. 550 gr. (1¼ lbs.) powder, and a bomb of 4 kil. (8¾ lbs.).

In Prussia it was shown in firing with the regulation charges, and diminishing at each fifty shots the exterior diameter of the chamber, that the phosphor-bronze cannon only changed their dimensions when the thickness of the metal was below that of the dimensions of the cannon of the same calibre made of steel.

The Belgian Government has adopted the phosphor-bronze for small arms and for the harness buckles of all their cavalry.

OXIDATION OF SILVER AND PLATINUM.*

By WILLIAM SKEY, Analyst to the Geological Survey of New Zealand.

I SHALL confine myself in this paper to a statement of results, and the considerations which led me to seek them, as I intend leaving the discussion of these in their various relations to certain debatable subjects for another opportunity, my investigations upon this matter being as yet incomplete.

A knowledge of the fact that gold and platinum readily combine with sulphur at a common temperature, and that the compounds thus formed cannot be detected by mere physical tests, suggested to me that oxygen may also combine with these metals under conditions somewhat similar, and in this manifesting none of the more distinguishing signs of chemical action has consequently to this time been overlooked.

Acting at once upon this suggestion, I forthwith made a series of experiments to test the correctness or otherwise of my suspicion, and the results of these experiments, showing them in the main, I believe, to be correct, I submit to your notice.

I should premise my statement of these results by informing you, in anticipation of what will in due course appear, that one of my principal tests for the oxidation of these metals is that known as the "mercury test," by which it will perhaps be remembered I had the honor of demonstrating before you experimentally the sulphurization of gold by sulphuretted hydrogen; and that this test is based upon the fact that mercury readily amalgamates with silver or platinum when in contact with them, but that if the minutest film of any substance intervenes between the two metals, amalgamation is either retarded or altogether prevented; thus, by the aid of this test, minute quantities of a substance enfilming either of these metals may readily be detected.

Commencing with silver, I ascertained the following facts regarding it:

1. That pure silver immersed for a few hours in distilled water, or in the purest water I could obtain, has its surface so modified that it will not amalgamate immediately afterwards.
2. That such an effect is not produced when either rain or spring water is used.
3. That silver thus modified by distilled water is brought back to the amalgamable state by contact for a short time with rain or spring water, also with acetic acid or ferrous sulphate, also by raising its temperature to about 500° F.
4. That electric currents are generated by this metal in saline water free from chlorides, iodides, or bromides, also in water charged with any of these salts.
5. That in dry air silver does not pass into this non-amalgamable state.
6. That spongy silver immersed in an aqueous solution of sodic chloride (in an agate vessel) soon renders it very alkaline.

These results, taken conjointly, signify, I think, undoubtedly that silver is a metal which oxidizes in a superficial way with far greater facility than we have heretofore considered possible.

Thus, in experiment 1, I hold this metal is oxidized by atmospheric oxygen contained in the distilled water used, and the oxides of silver not being reducible, or at least readily reducible, by mercury, amalgamation is prevented or greatly retarded. With water containing chlorides, in experiment 2, we must suppose the silver has also oxidized, but the oxide thus formed has been decomposed by the alkaline chlorides present, argentiferous chloride thus resulting as a secondary product, and this compound, being, as we know, readily decomposable by mercury, amalgamation proceeds with rapidity. However, in regard to silver thus acted upon by chlorides, I always noticed that amalgamation did not appear to proceed instantly when it was placed in contact with the mercury as clean silver does: there was, as it were, a momentary hesitation manifested by the mercury before amalgamation proceeded.

The effect of acetic acid and of ferrous sulphate in experiment 3 is perhaps referable to a solution of argentiferous oxide in the one case, and to its reduction in the other. At the same time, however, we must consider that basic and insoluble silver salts may form here; and these, being readily decomposable by mercury, amalgamation is not retarded. The facts, Nos. 4, 5, 6, I think, will be seen corroborative of the correctness of the conclusions I have above drawn.

I may state in further support of this conclusion that I have observed silver, as precipated from its nitrate, darken near the surface of the solution, and it is only colorless and lustrous where distant therefrom, or when overhung by masses of silver. This darkening I attribute to a superficial oxidation of the silver by the atmospheric oxygen which has permeated the solution used. This metal also, contrary to general belief in regard to it, decomposes mercuric chloride. All these results were in the first place obtained from the metal electro-plated from its pure cyanide upon silver wire; but afterwards, for greater certainty in the matter, I employed silver most carefully prepared, and by improved processes for pure silver. As electro-plated upon lengths of surgical wire, it is most easily worked, and being thus in a spongy form, its behavior with the mercury test can be minutely and readily observed. It is necessary of course to well wash this silver from alkaline cyanide by distilled water before using it in these experiments. I should inform you I could not observe that sunlight exerted an effect in any of these reactions, whether accelerating or retarding.

In regard now to the metal platinum, I ascertained that it is also passed to a condition in which it will not amalgamate, by giving it contact for a short time with distilled or ammoniated water, also with aqueous solutions of the alkalies, their carbonates or chlorides, while acids generally put it quickly back into an amalgamable condition; an elevation of its temperature to about 400° F. will also accomplish this.

Platinum also generates electric currents when paired with graphite in saline or alkaline solutions.

These facts, I think, show undeniably that platinum not only absorbs oxygen, as is already known, but that this absorption is, in the cases cited, a chemical one, an oxide or a suboxide of this metal being formed. That in the so-termed mechanical absorption of certain gases by platinum, platinic compounds are produced, is an idea which I have long since entertained.*

In conclusion, I would beg to inform you that, from a partial investigation of the behavior of gold in certain liquids, I believe this metal is also oxidizable under conditions somewhat similar to those under which I have stated silver to be, but the results of this investigation I will endeavor to communicate at our next meeting.

* Read before the Wellington Philosophical Society, January 29th, 1876.

CLEANING IRON-AMALGAM.

IN working certain classes of ores it frequently occurs that, under certain not well understood conditions, the iron enters the amalgam when amalgamated in iron pans, making cleaning in the usual way impossible. It seems that the iron does not come from the ore but from the shoes and dies of the pan; otherwise it could not be explained why no iron-amalgam is obtained from the barrel amalgamation—at least, never to such an extent as to form iron lumps in the crucible when the retorted amalgam is subjected to melting. This iron-amalgam seems only found in the case of roasted silver ores and raw gold ores. It is very magnetic, and the iron only loosely combined with the quicksilver, so that simple mechanical treatment, such as rubbing or grinding, is enough to separate the iron from the quicksilver; but this is too slow for practical work.

In answer to an inquiry, it may be stated that there are several different ways of treating this iron-amalgam, but that described by Mr. G. Kustel is quick, cheap, and perfect, and is as follows: A flat-bottomed pan like Knox's is put in motion without any water in it, and a bucketful of sifted ashes introduced. The well strained amalgam is then thrown in gradually, piece by piece, in proportion as it turns into powder. If the mixture assumes a dark color, or if the pulverization commences to go slow, another bucketful of ashes is added, and so on, until about 300 pounds are pulverized, which is effected in about half an hour. The gray, heavy powder is then taken out and another lot of 300 pounds of amalgam managed in the same way, and so on. In case the ashes are moist, a reaction in the mass is observed by the increase of temperature to a considerable degree. After the mixture is finished the powder is allowed to lay for an hour undisturbed, then some water admitted into the pan so as to cover the bottom about an inch deep. While the muller is in motion the amalgam powder is introduced by means of a scoop until about 300 pounds are charged. Water is added, if necessary, but not too much. Quicksilver is generally not required unless the amalgam was strained very hard. After a while the amalgam becomes more liquid by losing the iron, which blackens the water. After an hour's grinding some amalgam is taken out and examined, and if not quite clean another hour will do. A quarter of an hour before the discharge, more water and quicksilver is added—the quicksilver only for the purpose of easier discharge. It is not exactly necessary to work with charges of 300 pounds.

If the supposition is correct that the iron comes from the shoes and dies of the pan, then if a certain kind of ore is inclined to form iron-amalgam, this could be prevented by omitting the grinding; but in treating raw gold ore the grinding is indispensable; and in this case, if iron-amalgam is formed, an addition of ashes to the ore would probably keep the iron from entering the amalgam, as the ashes are the means of separating it. Treating silver ores, this last remedy could not be used for the same purpose, as too much of it would injure the amalgamation.—*Mining and Scientific Press.*

NICKELIZATION AND COBALTIZATION OF IRON AND STEEL.—M. F. Stolba.—Nickel may be deposited upon iron or steel without the aid of the battery by immersing the objects in a solution of zinc chloride and a salt of nickel, raising to a boil, and bringing the metal to be coated in contact with metallic zinc. A deposit of cobalt may be obtained by an analogous procedure.

* "Trans. N. Z. Inst.," Vol. iii., Art. xxxviii.

ON THE ACTION OF SEA WATER UPON LEAD AND COPPER.*

By WILLIAM H. WATSON, F.C.S.

WHILE numerous experiments have been been made and published from time to time as to the action of distilled water and various saline solutions upon lead and copper, so far as I know very few have been published as to the action of *sea water* upon them, hence my concluding to record the following:

The only published researches I have been able to find bearing upon this question are those by Dr. Crace-Calvert and R. Johnson, "On the Action of Sea Water upon Certain Metals and Alloys (*Proc. Manchester Lit. and Phil. Soc.*), and later those by Kaiser, "On the Action of Sea Water on Lead" (*Arch Pharm.* (3), vi., 405), from which he says that after exposing strips of lead to sea water for four days no lead could be detected in the water. He, however, does not mention the quantity of metal or the quantity of water used in the experiment, neither does he mention the method of testing.

The experiments of Calvert and Johnson were conducted as follows:—20 square centimeters of each metal, cleaned with great care, were taken and placed in separate glass vessels, immersed in equal volumes of sea water. After one month the plates were taken out, and any compounds that had adhered to the surface carefully removed; the plates were then dried and re-weighed—*the loss being estimated and taken as the quantity of lead dissolved.* To render the results obtained of more practical value, calculations were made, and the following table constructed by them, showing the amount of each metal dissolved by 100 liters of sea water by acting upon one square meter of each metal:

	Grammes.
Steel	29·16
Iron	27·37
Copper (best selected)	12·96
" (rough cake)	13·85
Zinc	5·66
Galvanized iron	1·12
Block tin	1·45
Stream tin	1·45
Lead (virgin)	trace
" (common)	trace

With regard to these experiments, we notice that the method adopted for the determination of the amount of metal dissolved was faulty—one by which small quantities could not be with certainty detected. This fact, although taking from the results some of their scientific value, does not deprive them of much practical interest.

The colorimetic method, based upon the depth of color produced with lead or copper on addition of ammonium sulphide, being capable of detecting exceedingly minute quantities of these metals in solution, was that adopted in the experiments about to be described, so that I am able to speak of the minute variations in the quantity of metal dissolved according to the length of time during which it was exposed to the water, and the results of my experiments show that the action of sea water upon lead and copper is exerted chiefly during the first few days of exposure, also—which appeared at first somewhat remarkable—that the quantity of metal in solution, after reaching its maximum, decreases when the metal is still exposed in the water.

The method of procedure may be described as follows:—Thin foil of lead and copper was used, cut into pieces two inches square, and thus exposing eight square inches of surface. In the instance of the copper foil it was effectually cleaned by immersing for a sufficient time in moderately dilute nitric acid, and afterwards washing in water. The lead was cleaned and made perfectly bright by rapidly rubbing with the back of a knife. The pieces were cleaned shortly before being immersed in the sea water, and until ready for such immersion were kept covered by pure water. The quantities of sea water (2,000 grain measures in each instance) were poured into beakers, and one of the pieces of foil, copper, or lead, as the case might be, was dropped into each. The beakers were then placed in a room above the laboratory, where they were covered by pieces of porous paper. The foil was occasionally moved about during the exposure.

I. *Lead.*—Even after the longest exposure—thirty-two days—no insoluble compound was suspended in the water or precipitated to the bottom of the beaker, but the surface of the foil was slightly coated with a deposit; it was tarnished. The standard solution of lead from which the comparison solutions were constructed was prepared by dissolving one grain of the lead foil in as small a quantity of nitric acid as possible and diluting with water to 2,000 measures; each 100 measures being then equal to 0·05 of a grain of lead. The following results were obtained:

Days Exposed.	Lead in Water.
4	0·000862509 grs.
7	0·001207500 "
14	0·001380000 "
32 (experiment 1)	0·0..0938750 "
32 (experiment 2)	0·000862500 "

These results show that from the fourteenth day of exposure to the thirty-second the quantity of lead in solution diminished (according to experiment 2) from 0·00138 to 0·0008625 of a grain, a quantity exceedingly small, but sufficient to distinctly show a diminution, and easily detected, by the method adopted, in the quantity of water used—2,000 grains.

I should explain that the determinations as above were made upon the contents of separate beakers, and in each case on the day the lead foil was removed from the water, so that they were not all made on the same occasion. I felt it desirable to execute a fresh series of experiments in order to prove the accuracy, or otherwise, of the conclusion with regard to the amount of lead in solution diminishing on the foil and water being exposed for a lengthened period. Beakers were prepared with water and lead foil (sea water of course) and exposed; but instead of determining the *quantity* of lead in solution, the lead foil was removed after the same lapse of time as in the former experiments just described, namely, after 4, 7, 14, and 32 days' exposure respectively, but the water from each exposure was kept, and the whole of the water samples tested with ammonium sulphide at the same time, and thus by comparing the several depths of color produced by the various samples comparative results were obtained; these confirming the former ones and supporting the conclusion that the amount of lead in solution in the water diminishes on prolonged exposure along with the metallic surface. The same fact may be applied in the case of copper, as will be presently shown.

The action of sea water upon lead is very slight, and by another experiment (by immersing in a fresh portion of sea water a piece of lead foil used in the former experiments which had become tarnished, and testing the water after some days' exposure) it appears that no perceptible action is exerted by sea water upon such tarnished metal.

II. *Copper.*—The experiments about to be described were conducted similarly to those on lead, and, therefore, upon that point I need not dwell. By the action of the sea water upon the copper a green deposit insoluble in water (or nearly so), but exceedingly soluble in dilute acids, was formed, and this contained, as will be presently shown, the chief portion of the copper dissolved. This deposit was somewhat rapidly formed at the commencement of the exposure (some being observed at the bottoms of the beakers even after only twelve hours' exposure); but, after a time, this green compound apparently ceased to form, giving place to a thin but not easily removable covering of a bronze color on the surface of the foil, on which the water ceased to act; on removing this tarnished foil, however, to some fresh sea water, action again commenced, resulting, as before, in the formation of a green-colored deposit. So as to find whether the bronze covering given to the copper by the sea water prevented or not the action of other waters upon the copper, one of the pieces of tarnished foil was immersed in 2,000 grain measures of soft river water, and into a similar quantity of the same water a piece of *bright* copper foil of the same size was placed. After the expiration of five days the water was examined. It had acted considerably upon the *bright* copper, but only slightly on the tarnished—the copper dissolved in one case being about half as much as in the other. The tarnished surface, then, does not prevent totally the action of soft water upon the copper; or the tarnish is itself acted upon.

Before testing, in each case the green compound was separated from the water, so that the amount of copper might be determined in each separately. The following results were obtained:

(*a*) Copper in solution in the water.

Days Exposed.	Copper.
4	0·00675 of a grain.
7	0·00350 "
14	0·00300 "
32	0·00300 "

Here we have an instance of the copper dissolved reaching its maximum, then between the fourth day and the seventh day diminishing from 0·00675 to 0·00350; but, as will be seen below, the green compound continued to form.

(*b*) Copper in the green deposit:

In order to determine the amount of copper in the compound, it was dissolved in a very small quantity of dilute nitric acid, and the solution thus obtained diluted with water to 4,000 measures; 100 measures of this solution were then taken and diluted to 1,000 measures, to which ammonium sulphide was added, and the tint compared with that produced similarly in a standard copper solution—the results thus obtained being multiplied by 40 furnish the quantity of copper in the whole of the deposit as follows:

Days Exposed.	Copper.
4	0·200 of a grain.
7	0·320 "
14	0·360 "
32	0·370 "

Adding the quantities of copper found in solution in the water to those found in the deposit, we obtain the following numbers:—

Days Exposed.	Copper.
4	0·20675 of a grain.
7	0·32350 "
14	0·36300 "
32	0·37000 "

As to the green deposit, I found it to consist chiefly of a chloride of copper, but I am at present unable to say what particular chloride, and as to its formation I may add that by keeping copper foil immersed in a solution of sodium chloride containing 53 grains in 2,000 of water (about the quantity present in sea water), no such deposit is formed, neither is it formed when copper foil is kept immersed for some time in a solution of magnesium chloride.

Having made calculations from results given above, I append tables showing the action of one gallon (70,000 grains) of sea water upon 280 square inches of each metal.

The quantities are expressed in grains.

I.—LEAD.

Days Exposed.	Lead in Solution.
4	0·03018750
7	0·04226250
14	0·04830000
32 (expt. 1)	0·03285625
32 (expt. 2)	0·03018750

II.—COPPER.

Days Exposed.	Copper in Solution.	Copper in Deposit.	Total Copper Dissolved.
4	0·28625	7·00	7·23625
7	0·12250	11·20	11·32250
14	0·10500	12·60	12·70500
32	0·10500	12·95	13·05500

* Read before the Manchester Literary and Philosophical Society.

CHEMISTRY.

State of Salts in Solutions.—M. D. Gernez.—The author finds that saturated solutions of sodic sulphate, prepared between 25° and 30°, or below, and left to cool, yield supersaturated solutions like those which have been heated beyond 33°. To prove this, it is sufficient to filter these solutions, and collect them in tubes recently washed or heated, and then cooled. We eliminate thus from the liquid, or from the sides of the vessel, the particles of sulphate of soda which might provoke crystallization. Solutions of sodic sulphate made at a temperature lower than 33°, and then left to evaporate in dry air, give crystals of a hydrate with 7 HO, like those which have been raised to a temperature above 33°. This result is obtained either by eliminating the accidental solid sulphate, as indicated above, or by raising the temperature of the saturated and filtered solution a few degrees, but still always keeping it below 33°. In this manner we obtain on evaporation merely the hepta-hydrated salt, even with solution made at low temperatures. Solutions made in the cold, *e.g.*, at 11°, introduced into one of the elbows of a W-tube, afterwards sealed at the lamp, and heated to 20° in contact with anhydrous sulphate contained in the other elbow, give the same hepta-hydrated crystals as those heated beyond 35°. The experiment is very decisive provided that the salt employed is perfectly anhydrous, and that the solution made in the cold does not hold any deca-hydrated crystals in suspension. These experiments prove that as regards the production of the two hydrates there is no difference between the solutions made below 33° and those which have been submitted to a higher temperature. We cannot, therefore, admit that the former are solutions of the deca-hydrated and the latter of the hepta-hydrated salt.

New Series of Acid Salts.—M. A. Villiers.—The author has obtained a series of acid salts formed by a neutral acetate with acetic acid and water. Of this series the biacetate of potassa of M. Thomsen, the triacetate of soda of M. Berthelot, and the triacetate of potassa of M. Lescœur, form parts.

Researches on Iodic Acid.—M. Berthelot.—In this paper, which is of considerable length, the author describes the results obtained on causing iodine to act upon potassa, when the formation of hypo-iodous and of iodic acids was observed. He examines then the reaction of iodic acid upon water and the alkalies, and compares the thermic formation of the oxy-salts derived from chlorine, bromine, and iodine, seeking to deduce new data for molecular mechanics. He finds that the main chemical circumstances of the formation of the compounds of oxygen with the halogens agree with thermic data.

Transformation of Ordinary Pyrotartaric Acid into Hydrobromate of Tribromated Ethylen.—M. E. Bourgoin.—The author infers that there exist three substances of the formula $C_4H_5Br_3$; the perbromide of acetylen resulting from the direct combination of acetylen with bromine, and remaining liquid in a freezing mixture of salt and ice; the hydrobromate of tribromated ethylen, probably identical with the bibromide of bibromated ethylen, solidifying about — 17°; the hydride of tetrabromated ethylen, which melts at 54·5°, a crystalline body corresponding to succinic acid.

New Group of Compounds, the Seleniureas, and Method of Determining Selenium in such Bodies.—Dr. P. Spica.—The author, in order to obtain seleniurea, sets out from seleniocyanide of potassium, which he prepares according to the process of Berzelius, modified by Crookes. He succeeds in forming two derivatives, which may be regarded as urea in which selenium is substituted for oxygen. These are monobenzyl-selenurea = $C_8H_{10}N_2Se$, and iso-dibenzyl-selenuren = $C_{12}H_{16}N_2Se$.

Purification of Manganic Chloride obtained from the Residues of the Preparation of Chlorine with Hydrochloric Acid and Native Peroxide of Manganese.—A. Pizzi.—The author, having separated the liquid by filtration from undissolved oxide of manganese, silica, etc., placed in the liquid zinc turnings. When the effervescence was over, the whole was heated to a boil for some time. The solution, yellow at first from ferric chloride, began to grow colorless, and then took a faint rose tint. The chloride of iron, like that of nickel, is decomposed in presence of zinc, whilst the chloride of manganese is unaffected. Having thus eliminated the iron, nickel, and the gelatinous silica, we have still in solution a part of the silicic acid, chlorides of zinc, lead, copper, cobalt, barium, and calcium, which metals are found in pyrolusite. The liquid is decanted off from any undissolved fragments of zinc, and to the solution is added pure acetate of soda along with some drops of acetic acid, and a current of sulphuretted hydrogen is passed through the liquid for some time. The zinc, lead, and copper are thrown down as sulphides, whilst the H_2S has no action on the chlorides of manganese, cobalt, barium, and calcium. The precipitate is thrown upon a filter and in the filtrate manganese and cobalt are precipitated with sulphide of ammonium, and the liquid is filtered anew. The precipitate is well washed to remove all traces of barium and calcium chlorides, and the second precipitate (of manganese and cobalt) is treated with hydrochloric acid. The sulphide of manganese dissolves, and is then separated by filtration from the sulphide of cobalt, which remains untouched.

Fuming Nitric Acid on Illuminating Gas.—T. Akestorides.—The author finds that by conducting the gas through cold fuming nitric acid—besides nitro-benzen, nitro-toluen, and other nitro compounds—considerable quantities of oxalic acid are formed. The presence of the latter is due to the oxidation of ethylen and the homologues of benzen.

Compounds Formed by the Metals of the Tantalum Group, and on the New Metal Neptunium.—R. Hermann.—The author gives in a lengthy paper the latest results of the researches on this group of metals, which he has continued during the past thirty years. He brings together a mass of evidence to prove the existence of the metal *ilmenium*, the discovery of which he announced a number of years since, and by characteristic compounds and reactions dispels in a great measure the doubts raised against the claim by Marignac's investigations on the subject. The substance regarded by the latter as niobium is shown to have consisted of a mixture of niobium and ilmenium, and in one case of pure ilmenium. These two metals were obtained in the form of a black powder by heating the potassic double fluorides with K and KCl and treatment with water. In this condition niobium contains 0·726 per cent. hydrogen and ilmenium 0·23 per cent. By heating in the air niobium is changed to Nb_2O_5, and ilmenium to Il_2O_5. While studying the peculiarities of these two metals the author discovered in a mixture of columbite and ferro-ilmenite from Haddam, Conn., a new metal, to which he assigns the name Neptunium. By fusion of the mineral with acid potassic sulphate, the hydrates of the metallic acids were separated out in the following proportions:

Ta_2O_5	32·39
Nb_2O_7	36·79
Il_4O_7	24·52
Np_4O_7	6·30
	100·00

The separation is accomplished as follows:—The hydrates are dissolved in HFl, and KFl is added. Upon the addition of 40 parts water the tantalum potassium fluoride separates out entirely. By successive crystallizations the greater portion of the ilmenium and niobium fluorides are removed, and a residual liquor is obtained, containing potassium-neptunium fluoride, with small quantities of the niobium compound. An addition of HNaO precipitates amorphous sodium neptunate and crystalline sodium niobate. On account of the insolubility of the neptunate in boiling water, it is

easily separated from the niobate, and changed into the hydrate by fusion with acid potassium sulphate. Neptunium possesses the general properties of the other metals of the group. The hydrate is insoluble in mineral acids, with the exception of HFl. The solution of the fluoride is not precipitated with H_2S. The hydrate of neptunic acid is neither colored nor dissolved by $(NH_4)_2S$. Tantalum fluoride and neptunium fluoride both yield with HNaO amorphous insoluble precipitates; ilmenium and niobium give soluble crystalline precipitates. The solubility of neptunium-potassium fluoride distinguishes it from tantalum-potassium fluoride. The atomic weight of neptunium, as afforded by the analysis of the double fluoride $4KFl+Np_2Fl_7+2H_2O$, is 118. According to Hermann the atomic weights of the whole group are as follows:—Ta, 176; Np, 118; Nb, 114·2; Il, 104·6. The colors imparted to beads of phosphorous salt in the inner flame of the Bunsen lamp by the acids of the four metals are—Ta, colorless; Nb, blue; Il, brown; Np, wine-yellow. The solutions of the sodium salts yield with tincture of gall-nuts the following characteristic precipitates:—Ta, light yellow; Nb, orange; Il, brick-red; Np, cinnamon-brown. The hydrates of the acids of Nb, Il, and Np yield with HCl and tin-foil deep blue solutions, while no colornation ensues with tantalic acid hydrate.

Preparation of Hydriodic Acid.—H. Kolbe.—The method recommended by most text-books of adding gradually 20 parts of iodine to a mixture of 15 parts of water and 1 part of red phosphorus, is found to be entirely incorrect. The author heats 1 part of yellow phosphorus with 10 parts of iodine, and, after cooling, adds 4 parts of water. On warming, pure hydriodic acid is given off in quantities.

CARBON—HYDROGEN—OXYGEN.

SIMPLE words these, but of how much import to us and our surroundings! In their combination, the most diverse productions which concern us in our living. Carbon or charcoal, hydrogen and oxygen, or water. The union of these form compounds differing from each other in looks, taste, smell, and chemical reactions. Thus, acetic acid is composed of 12 atoms of carbon, and 24 atoms of hydrogen and 12 atoms of oxygen, or charcoal and water; not, strictly speaking, charcoal and water, but that a re-arrangement of these atoms would represent charcoal and water. Again, sugar is composed of these very same elements in different proportions, thus: Carbon, 12 atoms; hydrogen, 22 atoms; oxygen, 11 atoms. These facts may be represented as below:

C, Carbon.
H, Hydrogen.
O, Oxygen.
H^2 O, Water.
C_{12} H_{24} O_{12}, Acetic Acid or Grape Sugar.
C_{12} H_{22} O_{11}, Cane Sugar.

Still more wonderful, we have fruit or grape sugar, composed of identically the same atoms as acetic acid—the sour principle of vinegar.

What more different, apparently, than starch and wood? Yet cellulose, or pure woody fiber, and starch are similarly composed of C 12 H 20 O 10. Yet the one we use as food for our bodies, the other but as a waste product, as in sawdust. Yet the fats are composed in turn of exactly the same elements as in starch and woody fiber. From these same elements are also formed chlorophyl, which is the green principle of plants; also mucilages and gums; one class of fibers, as linen, jute, and ultimately paper; oxalic acid, so poisonous, if taken into the stomach; and citric acid, so grateful in lemonade.

Let us group some of these wonders in a table, reminding the reader to read the letters as indicating the substances, C for Carbon, H for Hydrogen, O for Oxygen, and the figures the proportional parts which are combined:

Acetic Acid, C_{12}, H_{24}, O_{12}.
Oxalic Acid, C_2, H_2, O_4.
Citric Acid, C_6. H_8, O_7.
Woody Fiber, C_{12}, H_{20}, O_{20}.
Starch, C_{12}, H_{20}, O_{10}.
Mucilage, C_{12}, H_{22}, O_{10}.
Fruit Sugar, C_{12}, H_{26}, O_{13}.
Cane Sugar, C_{12}, H_{22}, O_{11}.
Gum Arabic, C_{12}, H_{22}, O_{11}.
Olein (Fat), C_{57}, H_{104}, O_6.

We can thus form an idea of the wonderful resources of Nature in forming useful compounds; and this list is but a very small one compared to what might be offered. Under the same composition, many products which affect us differently, given but a slight difference in the quantity, and innumerable new compounds.

Add another element to these, nitrogen, and we have flesh, albumen of egg, casein, and the whole tribe of albuminoids, which enter into our foods and the structure of our bodies. From these elements, or a portion of them, are formed the ammonia and the nitric acid so essential to our crops.

Truly a wonderful thing this Nature within which we exist, and of which we form a part; and a wonderful science this chemistry which unfolds to us these secrets of Nature.—*Scientific Farmer.*

TREATING SPENT OXIDE OF IRON TO OBTAIN SULPHUR AND PRUSSIAN BLUE.

THE spent compounds of iron which have been used in the purification of illuminating gas contain often 40 per cent. and more of precipitated sulphur, which has heretofore been employed for the manufacture of sulphuric acid, by burning it directly to sulphurous acid; and it has also been extracted from the spent oxide by means of carbon bisulphide and by distilling off the latter and recovering the sulphur itself. The method invented by Mr. G. T. Gerlach, Ph.D., of Kalk, near Cologne, for recovering the sulphur, consists in heating this spent oxide in retorts of iron or clay (for instance, retorts which are used in the manufacture of illuminating gas) and in distilling off this sulphur, while at the same time superheated steam is introduced. Without employing superheated steam the vapors of the sulphur evaporate slowly, whilst by employing superheated steam the distillation of the sulphur is quick, and the sulphur evaporates very easily. Whilst in closed steam boilers the steam pressure is augmented in the same proportions as the temperature is raised; superheated steam can be furnished of any desired temperature without any tension or pressure. By superheated steam the temperature is quite independent of its tension. If common steam is let through iron pipes heated to red heat, the steam leaves the said pipes having the same temperature as the red hot iron. Such superheated steam is invisible, and is exactly like a gas. In a current of such superheated steam wood and paper become brown, and sealing-wax, and even lead and tin, are melted.

To recover the sulphur and Prussian blue, or prussiate of potash, the humid material is, according to Dr. Gerlach's process, ground in a mill to form a fine mass, which is lixiviated by means of water. If the mass contains ammoniac in a free state the lye can be neutralized by an acid. By this lixiviation the soluble ammoniac salts are obtained, which are by evaporation crystallized or employed in the usual manner by any suitable copper salt for the precipitation of sulphocyanite of copper or distilled with lime to obtain volatile ammoniac. Water is again poured on the lixiviated mass, and simultaneously caustic soda or carbonate of soda or lime is added to the mass. Already by the cold digestion with such alkalies the insoluble prussiates are converted into soluble prussiates. The clear liquid is drawn off and treated with an acid until the same is neutralized or gives a weak acid reaction. The weak acidified liquid is soon clouded by precipitated prussiates and sulphur. This dirty green precipitate might afterwards injure the beautiful clear color of the Prussian blue, and is, therefore, carefully removed. The clear solution, which if necessary is filtered, is then acidified and treated by a solution of perchloride of iron, or by a small surplus of any other soluble salt of oxide of iron, such as sesqui-chloride of iron. He thus obtains Prussian blue, which in consequence of its purity has a dark blue color, and when dried shows a copper luster on its fractures. He employs this product as Prussian blue itself, or converts it into prussiate of potash.

For the manufacture of the prussiate of potash the spent oxide has hitherto been treated directly by caustic potash or by carbonate of potash, and the lye has been evaporated, or the lime containing spent oxide has been treated with carbonate of potash, and after filtering off the carbonate of lime the lye has been evaporated. In both cases great masses of dilute lye have to be treated, and there is danger of producing a decomposition of the prussiate of potash. These lyes contain also sulpho-cyanide of potash, which is to be found again as a contamination in the prussiate of potash. Consequently he prefers to precipitate the acidified solution by sesqui-chloride of iron to wash out the Prussian blue, and to obtain by this washed Prussian blue the yellow prussiate of potash by any known manner. The spent oxide of iron lixiviated in this manner contains a great quantity of sulphur in a free state. The mass is dried and then, as above described, distilled for recovering the sulphur. During this distillation superheated steam is led over the heated mass, by which means the sulphur to be recovered is distilled off in a very short time.

The essential features of Dr. Gerlach's process, as compared with those heretofore used, is that he does not employ any solvent for the sulphur, but distills off the sulphur together with steam. In the same manner the sulphur is recovered from the gas lime, if lime in place of iron is used for desulphurating the illuminating gas, and in the like manner this method can be employed for the recovery of sulphur from any other masses or ores containing sulphur. The lixiviated and desulphurated mass is heated whilst air is admitted, and the product is a beautiful brown coloring mass, *caput mortuum*, which can be employed as a paint. If the sulphur only is to be recovered from the spent oxide, and if the recovery of the cyanides is dispensed with, it is advisable to dispense with the crushing or pulverizing of the spent oxide in a mill. The desulphurated masses can be used anew for the purification of the illuminating gas.

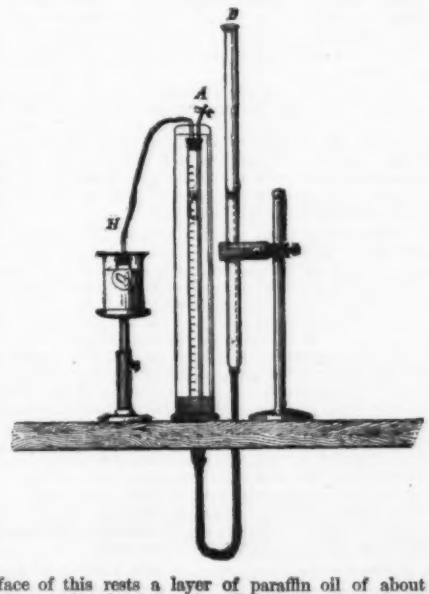
DETERMINATION OF AMMONIA BY HYPOBROMITE OF SODIUM.

By E. FRANCIS.

THE gas apparatus constructed by E. Francis is shown in Fig. 1.

A finely graduated burette of proven accuracy, A, is firmly fixed in a hole in the table, through which passes a caoutchouc connection to the plain tube, B, of equal caliber. The latter can be raised or lowered through a similar hole and is supported by a common clip. The tubes contain a convenient quantity of water, and on each

FIG. 1.



surface of this rests a layer of paraffin oil of about 0·5 centimeter in depth.* An Erdmann's float facilitates accurate measurement. The burette is closed by a caoutchouc stopper fitted with two tubes, one of which leads by a flexible tube to the gas bottle, H, or to the apparatus shown in Fig. 2; while the other, furnished with a pinch-cock, serves for the adjustment of level after the gas bottle is connected.

The burette is surrounded by a cylinder of water, and the gas bottle is cooled by immersion in a separate vessel, a disk of sheet lead slit to the centre keeping it in position.

* Mineral oil is much preferable to other oils, as it travels along the tubes without adhering.

The flask of an ordinary Parnell's carbonic acid apparatus makes a convenient gas bottle, and the tube inclosed is formed of the lower part of a five-eighths of an inch test-tube, broken unevenly, so as to be readily introduced by the fingers while at the same time admitting of an easy transference of liquids.

FIG. 2.

The apparatus represented by Fig. 2 may often replace the simple flask and tube with advantage, as, for instance, in the estimation of urea in urine. It consists of a small burette with a fine orifice passed a short way through a caoutchouc stopper fitted to a flash provided with a lateral tube. A vulcanized tube connects the mouth of the burette to a short glass one, also passing through the stopper. Hypobromite solution being placed in the flask, the burette is filled by disconnecting and applying suction to the end of the vulcanized tube at *b* while the point of the burette (which need not be removed from the stopper) is dipped in the urine. A pinch-cock placed as shown in the figure regulates the passage of fluid. The flexible tube being rejoined and the stopper holding the filled burette replaced in the flask, the latter is ready for connection by the lateral tube to the gas apparatus. Successive measured quantities of urine or other liquid can then be submitted to the solution in the flask, and thus a number of determinations of gas be made at one operation.

The conditions regulating gaseous determinations of urea and carbonic acid have been so thoroughly elucidated by late writers in the case of the former by Russell and West, Apjohn, and Dupré, and of the latter by Scheibler, Warrington, and Pruen and Jones—that it would be superfluous to enter upon them here, and it needs but to say that the determinations can be effectively carried out by the above apparatus.

The determination of ammonia by hypobromite has not however, received the same attention.

Ammonia, unlike urea, yields up the whole of its nitrogen under the treatment; the process is, therefore, more precise in the one case than in the other, and is easy, rapid, and accurate.—*Chemical News.*

THE CHEMISTRY OF THE POTATO.

THE London *Agricultural Gazette* gives a summary of recent German investigations with regard to the chemistry of the potato. Some of these are of practical interest, and we condense portions of the article for the benefit of our readers.

The value of the potato for the starch manufacturer, and also for stock feeding, depends solely on the amount of starch it contains, and this varies greatly. Holdefleiss, who has examined many varieties of potatoes, found the total dry matter to vary between 18·87 and 35·68 per cent. of the tuber, and the starch from 14·49 to 29·39 per cent. Other experimenters have found even wider variations. A ready way of determining the percentage of starch is a desideratum, and it is said that the *specific gravity* is found to stand in a pretty constant relation both to the total dry matter and the starch. Tables have been prepared by Pohl, Balling, and latterly by Holdefleiss, which show the percentage of starch which corresponds to each specific gravity. The most accurate of these tables is that of Holdefleiss, of which the following is an abstract:

Specific gravity of tuber.	Dry matter per cent.	Starch per cent.
1·07	18·02	14·36
1·08	19·46	15·37
1·09	21·32	16·88
1·10	23·48	18·76
1·11	25·82	20·86
1·12	28·23	23·05
1·13	30·59	25·17
1·14	32·79	27·09
1·15	34·71	28·67
1·16	36·42	29·76

"The specific gravity of potatoes can be ascertained roughly by putting a number of clean potatoes into strong salt and water, and then diluting the liquor till half of the potatoes sink to the bottom, while the rest float. The specific gravity of the salt and water, as ascertained by a hydrometer, will then be the mean specific gravity of the potatoes taken. A more exact method is to ascertain the weight of water displaced by a known weight of potatoes."

Another interesting subject is the cooking of the potato, on which Wagner and Schäffer have been lately experimenting. The value of the tuber as an article of food depends not only on the amount of starch but on the potash salts it contains, and it is important that these salts should not be lost in cooking. The writers we have mentioned have cooked potatoes both by steaming and boiling, the potatoes being at one time peeled and at another time in their skins, and have determined the loss of potash and phosphoric acid. The results were as follows, the figures representing the percentage of loss:

	Potash.	Phosphoric acid.
Potato not peeled, steamed.....	·69	·08
Potato not peeled, boiled.	2·32	1·12
Potato peeled, steamed.....	6·93	4·57
Potato peeled, boiled.....	33·33	22·87

The potato when protected by its skin suffers little loss even when boiled, but when the skin is removed one third of the potash is lost during boiling Peeled potatoes ought clearly to be steamed if this element is not to be wasted. When potatoes are baked no loss of potash salts can occur.

These salts, we may add, are the anti-scorbutic ingredient of the potato, and is especially important that they should be retained when a diet of that specific character is required.

CHEMICAL SOCIETY, LONDON.

May 3, 1877.

DR. GLADSTONE, President, in the chair.

Gas Analysis.—Mr. J. W. Thomas read a paper "On Some Points in Gas Analysis." The author, during the examination of the gases occluded in Bovey lignite, found, after removing the carbonic acid, an absorption of 1·3 to 3·8 per cent. by pyrogallic acid and potash; as no oxygen was present, he proceeded to investigate the cause of this absorption. He found that pyrogallic acid does not liberate carbonic acid from the alkaline carbonates; moreover, oxygen is completely absorbed, though slowly, by a solution of pyrogallic acid and potassic carbonate, providing an excess of the acid is not present. Oxygen is absorbed completely and rapidly by caustic potash and pyrogallic acid in the presence of potassic carbonate, if an excess of caustic potash be present. The author next investigated the formation of carbonic oxide during the process of absorption, and finds that the error caused thereby can be reduced to less than 0·5 per cent. by using at least twice as much caustic potash as pyrogallic acid and agitating the tube so as to hasten absorption. Nitric oxide is absorbed by a solution of pyrogallic acid and caustic potash; the absorption is, however, not complete; owing to the formation of some nitrous oxide, the reaction being, probably, $N_2O_2 = O\,N_2 + O$. Nitric oxide is slowly absorbed by pyrogallic acid and potassic carbonate. Of course nitric oxide and oxygen could not co-exist in a gaseous mixture, but if only a small quantity—say 3 per cent.—of nitric oxide be present, it is difficult to determine whether the gas is oxygen or nitric oxide, as both would be absorbed by pyrogallic acid and potash. The author, therefore, always adopts the method of adding a known volume of oxygen to the mixture to be analyzed after absorbing the carbonic acid with potash, any decrease of volume will be due to the presence of nitric oxide. In conclusion, he gives the following precautions: An excess of caustic potash should always be present, and the absorption accelerated by agitation. The alkaline solution of pyrogallic should be used in moderate excess, so as to increase the rapidity of absorption and prevent the formation of carbonic oxide. The absorption should be complete in five to ten minutes. The best liquid is a saturated solution of caustic potash and one part of pyrogallic acid to five parts of water.

Decomposition of Nitric Oxide.—The next paper was by Dr. Russell and Mr. W. Lapraik, "On Experiments on the Decomposition of Nitric Oxide by Pyrogallate of Potash." The nitric oxide was prepared by the action of sulphuric acid on nitrate of potash and ferrous sulphate. Its purity was always tested by its total absorption in a solution of ferrous sulphate. Different volumes of gas were exposed to the action of pyrogallate of potash; it was found that 58 to 59 per cent. of the gas was absorbed. The authors then tried the action of pyrogallate of potash, fully saturated with oxygen, in this case 76 per cent. of the nitric oxide was absorbed. The action of potash alone was now investigated, 75 to 77 per cent. of gas was slowly absorbed. The action was substantially the same in the cold and when heated either at the ordinary pressure or in sealed tubes. The residual gas consisted, roughly, of 90 per cent. nitrous oxide, 2 per cent. nitric oxide, 8 per cent. nitrogen. The action of water alone in sealed tubes heated in a water bath for a fortnight and remaining unopened four months, set up the same decomposition, but it was not complete, and more nitrogen was formed. Pyrogallic acid alone has no action on either nitric or nitrous oxide, and alkaline pyrogallate has no action on nitrous oxide. The authors concluded by stating that the probable action of the alkaline pyrogallate is to convert the nitric oxide into half its volume of nitrous oxide, but that simultaneously another more obscure action occurs either from the excess of potash or from certain compounds formed by the action of the oxygen on the pyrogallate. Practically, in the gases obtained by burning a water residue, a contraction of volume, on introducing alkaline pyrogallate, does not prove the presence of oxygen.

Mr. Thomas remarked that, by using caustic potash absolutely free from carbonate, he had succeeded in obtaining the theoretical quantity, 50 per cent. of nitrous oxide; but if old alkaline pyrogallate was used a larger quantity of gas was absorbed.

Dr. Russell, in reply to Mr. Neison, said the nitric oxide used was always tested to see whether it was completely absorbed by a solution of ferrous sulphate.

Dr. Armstrong was inclined to think that the reaction was not a case of simple deoxidation, but that the potassic hydrate played some part in the decomposition.

Naphthaline.—Mr. Groves read a paper by Dr. Stenhouse and himself, entitled "Contributions to the History of the Naphthalene Series, No. 1, Nitroso-*B*-Naphthol. After attempting to prepare this substance by Fuchs' process—*Deut. Chem. Ges. Ber.* viii., 625 and 1026—with results far from satisfactory, the authors devised the following process, which yielded good results: One part of pure *B*-naphthol was dissolved in ten parts of boiling water by means of one part by measure of caustic soda, sp. gr. 1·323, cooled and poured into one or more parts of water. This solution was mixed intimately with a liquid containing two parts by weight of 15 per cent. nitrosyl sulphate solution in 200 parts of water. After standing twelve to twenty hours, the precipitate of crude nitroso-*B*-naphthol was collected on a linen filter and washed with cold water. This was purified, in the first instance, by solution in 200 times its weight of light petroleum at 40°, filtering, and precipitating with an alcoholic solution of ammonia. This method of purification was unsatisfactory. No evidence could be obtained of the existence of a second isomeric nitroso compound. Other solvents were equally useless for purifying the crude product. The authors finally obtained the body pure by precipitation as a barium compound from a solution in dilute alkali; this compound, after decomposition with an excess of hydrochloric acid and washing, was re-dissolved, re-precipitated, etc., a second and third time; finally the nitroso-*B*-naphthol was obtained pure. The yield of pure substance is about half the weight of the naphthol originally taken. Full details, attention to which is necessary to secure success, of the preparation and purification are given by the authors. Analysis indicated the formula $C_{10}H_6(NO).OH$; the hydrated substance crystallizes in minute brilliant yellow needles which lose water at a gentle heat and become brown. The anhydrous compound obtained by crystallization from alcohol, etc., forms thin orange brown plates or short thick prisms, melting at 109·5. Nitroso-*B*-naphthol is slightly soluble in water, easily in carbon disulphide, benzine, ether, acetic acid, and hot alcohol, and sparingly soluble in light petroleum, it dissolves in cold concentrated sulphuric acid without alteration, but is decomposed by heating with concentrated nitric acid; it forms green compounds with the alkalies and alkaline earths; by treating nitroso-*B*-naphthol carefully with dilute nitric acid, mono-nitro-*B*-naphthol is prepared as a pale yellow crystalline powder, or in orange brown anhydrous plates. It melts at 96°. Other compounds are formed by the action of nitric acid on nitroso-*B*-naphthol, which the authors have not yet completely investigated. By treating the barium compound of nitroso-*B*-naphthol, suspended in dilute ammonia, with hydrogen-sulphide for an hour, an amido compound was formed; on dissolving this body in dilute sulphuric acid, and pouring the liquid into a 10 per cent. solution of potassium, dichromate *B*-naphthaquinone separated in bright orange needles, melting at 96° Cent.; analysis gave the formula $C_{10}H_6O^2$. By treating this new substance with hydriodic acid, a hydroquinone was prepared. On boiling with nitric acid, it is oxidized into phthalic acid. The authors point out that this is the first instance of two isomeric quinones (a naphthaquinone, which is readily volatile, having previously been prepared by Groves) derived from the same hydrocarbon.

On Asbestos Cardboard and its Uses in the Laboratory, by W. N. Hartley. This substance, specimens of which were exhibited about $\frac{3}{16}$ in. to $\frac{1}{4}$ in. thick, resembles grayish cardboard, but has a soapy feel, like steatite. It can be used for making crucible supports and baths, muffles, retort supports, etc. It can be cut with corkborers or scissors; by moistening with water it can be moulded to any shape; after moistening, it should be gradually dried and ignited, to get rid of organic matter. It stands the ordinary wear and tear of the laboratory well. It is formed principally of asbestos fibers. Mr. Hartley, in reply to various questions, stated it could be obtained from the manufactory, 31 St. Vincent Place, Glasgow, at 4*s.* per pound.

DEUTSCHE CHEMISCHE GESELLSCHAFT, BERLIN.

APRIL.

PROF. A. VOGEL exhibited a simple method for the "*Detection of Small Quantities of Carbon Monoxide in the Air*," based upon the alteration in the spectrum of blood caused by the absorption of this gas. The spectrum of pure blood shows two sharply defined bands between the lines D and E in the yellow field. By the absorption of CO, a slight movement of the bands in the direction of the red part of the spectrum is caused. If $(NH_4)_2S$ be added to pure blood, the spectrum displays a single band situated midway between the positions of the former pair, while no such alteration occurs in the presence of CO. In order to detect the presence of this gas in a room, a dilute aqueous solution of blood—a single drop afforded by a puncture in the finger suffices—is shaken in a test-tube with the air of the apartment, and, while held between a lamp and an ordinary pocket spectroscope, two drops of $(NH_4)_2S$ are added. The reaction is so delicate that the presence of 0·3 per cent. CO in the air is sufficient to prevent the disappearance of the two bands.

Dr. A. Franck stated that, in the course of observations '*On Disintegration of Pumice*," he had found that the rapidity of decomposition was dependent on the alkaline ingredients, and that it was three times greater in the case of potash than in that of soda. The presence of lime appeared to increase the rapidity of the removal of the alkalies.

V. Merz and W. Weith communicate "*Some New Methods of obtaining the Nitriles of the Aromatic Hydrocarbons.*" These consist in (1) conducting cyanogen into boiling hydrocarbons; (2) in exposing the monochloro- or monobromo-derivatives to the action of cyanides in sealed tubes, at 250° to 400°—a process yielding 20 per cent. of the theoretical amount; and (3) in leading the vapors of these halogen derivatives over a melted mass of sand and ferro-cyanide of potassium. The latter method yields, by distillation, a substance which—although not showing by analysis the composition of a nitrile—is oxidized into benzoic acid. The hydrocarbons form, with ClCN and BrCN, the halogen derivatives and HCN.

H. Plath, "*On Madder Coloring Matters.*" The purpuroxanthic acid of Schunck and Rœmer is obtained from crude purpurin by suspending the latter in glacial acetic acid, adding a few drops of fuming nitric acid, and boiling. The solid matter gradually dissolves accompanied by an escape of gas, and on addition of water to the cold solution the purpuroxanthic acid is precipitated. The author's experiments show also conclusively the difference of purpurin hydrate and pseudo-purpurin. The latter is shown, by heating with water and devolopment of CO_2, to contain a carboxyl group.

V. Griessmayer, "*On the Peptons of Malt Infusions.*"—The author finds that the protein substances of beer and infusions of kiln-dried malt consists of (1) a malt pepton, distinguished from ordinary pepton by optical inactivity, indifference towards the biuret reaction, and precipitation with sodic sulphate and acetic acid; and (2) a malt para-pepton, distinguished from ordinary para-pepton by optical inactivity and precipitation with alcohol.

A. Emmerling, "*On Phyto-Chemical Processes.*" The author has conducted a series of experiments with the view of ascertaining the peculiar process by means of which plants exert a solvent power on various insoluble constituents of the soil when brought in contact with the roots. This reaction is considered to be chiefly due to the vegetable acids, especially oxalic acid, but to be also dependent on the presence of small quantities of nitrites (which the author has previously shown are capable of being decomposed in vegetable juices by oxalic acid, under formation of free HNO_2), or possibly other soluble salts. Iceland spar was placed in an extremely dilute solution of oxalic acid, and was attacked in only the slightest degree. On the addition of minute quantities of HNO_2 or KNO_2 a comparatively rapid decomposition ensued, the nitric acid releasing the carbonic acid, and then surrendering the lime to the oxalic acid. This ability of small quantities of certain mineral salts to lend a decomposing power to oxalic acid is regarded then as explanatory of the above-mentioned phenomenon.

R. Nietzki, "*Amido-azo Compounds in the Toluen Series.*" Ortho-amido-azo-toluen, $C_{14}H_{15}N_3$, was prepared by passing a stream of nitrous acid through ortho-toluidin. It is insoluble in water, crystallizes in yellow laminæ from alcohol, and melts at 100°. Diazo-amido-toluen, when brought in contact with para-toluidin salts, does not yield an amido-azo compound. With ortho-toluidin salts, however, it forms ortho-amido-para-azo-toluen, $C_7H_7.N..N.C_7H_6(NH_2)$, a body closely resembling amido-azo-benzine. With aniline salts, a similar body, amido-benzine-para-azo-toluen, $C_7H_7.N..N.C_6H_4(NH_2)$, is obtained, which crystallizes in dark yellow needles with a beautiful blue reflection, and gives finely colored derivatives. The two amido-azo-toluens yield with aniline salts, coloring matters, isomeric, but not identical with rosaniline. The solutions of all these compounds are rendered colorless by boiling with zinc, but regain their colors by exposure to the air.

F. H. van't Hoff, "*Chloro-bromo-Carbon.*" The author obtains this compound by the action of bromide on trichloracetate of potassium—

$$CCl_3.CO_2K + Br_2 = CCl_3Br + CO_2 + XBr.$$

Chlorine and iodine chloride produced small quantities of CCl_4. Iodine caused a slight formation of C_2Cl_6.

"*The Limiting Plane in the Formation of Ethers.*" Mathematical considerations on ether formation, based on Berthelot's investigations in this direction.

V. von Richter, "*On Keton Acids.*" The author has sought in vain to obtain synthetically acids identical or isomeric with pyro-racemic acid, $C_3H_4O_3$, by preparing a possible methyl keton acid, $CH_3.CO.COOH$, from monochloraceton, and an ethylen-oxide-carbonic acid, $COOH.(CH)(CH_2)O$, from epichlorhydrine. Equally unsuccessful has been his attempt to change pyro-racemic acid into dichloropropionic acid by the action of PCl_5.

E. Baumann, "*On Phenol.*" The statement of Runge, the discoverer of phenol, that it does not decompose alkaline carbonates, is found to be true only at ordinary temperatures. By boiling phenol with a solution of potassic carbonate the CO_2 was set free, and potassium phenylate was formed. The formation of potassium phenyl-sulphate by the action of potassium phenylate on potassium pyrosulphate is found to be a universal reaction for all bodies containing a phenol-hydroxyl group. The author has discovered that phenol is a constant companion of indol and several other substances resulting from the putrefaction of albuminous bodies with water and pancreas, at 40°. 100 grms. pancreas and 100 grms. fibrine yielded 0·073 grm. of tribromo-phenol.

R. Fresenius, in reply to a recent communication from H. Vohl "*On H²S in Mineral Waters*," adduces evidence to show that in mineral springs H_2S occurs in company with free CO_2, bicarbonate of soda, and ferrous bicarbonate.

S. M. Losanitch, "*Action of Nitric Acid on Compound Ureas, Urethane, and Guanidins.*" Carbanilid, sulphocarbanilid, dinitro-sulpho-carbanilid, and triphenyl-guanidin, all yield by this reaction tetra-nitro-carbanilid, $CO[NHC_6H_2(NO_2)_2]_2$. Mono-sulpho ethyl-phenyl-urethane is changed into dinitro-phenyl-ethyl-urethane.

A. B. Baeyer has prepared from furfur-propionic acid, by the action of Br and Ag_2O, "*Furfuronic Acid*," $C_7H_4O_4$, crystallizing in colorless needles and melting at 180°. By reduction with sodium amalgam it is changed into hydro-furfuronic acid, $C_7H_{10}O_5$, a colorless crystalline, very soluble substance.

AKADEMIE DER WISSENSCHAFTEN, VIENNA.

E. LIPPMANN and J. HAWLICZEK, "*Artificial Oil of Almonds.*" By changing the artificial oil of almonds obtained from the oxidation of $C_6H_5CHCl_2$, into benzyliden chloride, as well as by the oxidation products, and determination of the specific density, it is shown to be physically and chemically identical with the natural product.

E. Lippmann and J. Hawliczek, "*Nitro-benzoyl.*" By the action of HNO_3 and H_2SO_4, on oil of almonds the authors obtain, besides meta-nitro-benzoic aldehyd, the compound $C_7H_5(NO_2)O$ in the form of a heavy oil. It is insoluble in water, possesses a high specific gravity, does not combine with the acid sulphites of the alkaline metals, and by oxidation yields benzoic acid and nitric acid. In structure and deportment it is analogous to chloro-, bromo-, and iodo-benzoyl.

J. Plank, "*Experiments on the Thermo-conductive Powers of N, NO_2, and NH_3.*" The results with N and NO_2 coincide with the theoretical deductions of Boltzmann. For mixtures of NO and NO_2 the law of arithmetical means applies. With NH_3 much lower figures were obtained than those deduced from Boltzmann's or even Maxwell's formulæ.

M. Herez, "*Behavior of some Ketons towards Oxidizing Agents.*" The results of a large number of experiments on different ketons of the fatty series, with a variety of oxidizing agents, show the correctness of Popoff's law, viz., that the alcohol radical containing the least amount of carbon remains joined to CO and forms one acid, while the radical containing the largest amount of carbon is oxidized to the second acid. Oxidation is, however, not confined to the formation of the two acids. In all cases CO_2 was formed, and lower homologues were present in small quantities. The author finds that all fatty acids are oxidized to a certain degree by sulphuric acid and potassium bichromate, contrary to the statement of Thorpe and Chapman.

G. Niedrist, "*Action of Water on the Halogen Compounds of Alcohol Radicals.*" Compounds with ethyl, isopropyl, and isobutyl are easily decomposed at 100° to 120°, forming the corresponding alcohols and hydrogen acids. Amyl chloride is attacked with difficulty, and amyl iodide is scarcely affected. At 150° ethylen-bromide undergoes the following decomposition, attended with a slight formation of aldehyd:—$C_2H_4Br_2 + 2H_2O = C_2H_4(OH)_2 + 2BrH$.

F. Zeidler, "*Behavior of various Amylens towards Oxidizing Agents.*" The amylen obtained from optically inactive amyl alcohol with $ZnCl_2$ yields carbonic, formic, acetic, propionic, butyric, oxalic, and succinic acids. That obtained by the action of alcoholic soda on amyl iodide prepared from optically inactive amyl alcohol yields carbonic, acetic, propionic, butyric, oxalic, and succinic acids. The amylen prepared by the action of phosphorous pent-oxide on ethyl-amyl-ether gives carbonic, formic, acetic, propionic, and oxalic acids.

J. DONATH, "*Decomposition of Hydroxylamine by Alkaline Cupric Solutions.*" Reduction to cuprous oxide, accompanied by a lively development of pure N_2O occurs even in the cold. Volumetric analyses coincided with the decomposition—

$$2NH_3O + O_2 = N_2O + 3H_2O,$$

from which fact the author considers that no hydroxyl group is contained in hydroxylamine, but that the oxygen united with the nitrogen solely."

H. Brücke, "*Contributions to Chemical Statics.*" Theoretical considerations based on the action of various acids, at different temperatures, on the violet solutions of ferric salicylate.

J. Pereluj, "*Diffusion of Vapors through Earthen Cells.*" The observations were made in a graduated tube, the sides

of which were coated with soap solution, a disk of mica resting on a soap film serving to mark the changes in volume. Ether gave results varying from Graham's law. Chloroform yielded numbers closely coinciding with those reckoned from the theoretical specific density. Experiments conducted at various temperatures, when the air in the interior of the apparatus was saturated with aqueous vapor, showed that the velocity of diffusion of aqueous vapor is dependent on the temperature in the same degree as the maximum of tension. After determining the constant of an apparatus in dry air, an observation made in ordinary air would serve to determine the relative amount of moisture present.

A. V. Obermayer, "*Friction on Viscous Bodies.*" The inner friction of pitch is shown to be subject to the same laws as the friction of liquids. The inner friction of merely soft bodies varies notably from these laws.

P. C. Puschl, "*Latent Heat of Vapors.*" The author finds that if a mixture of vapor and liquid passes through the following series of changes—viz., expansion by constant temperature, elevation of the temperature by constant volume, compression to the original volume by this elevated temperature, and cooling to the original temperature—the external labor required is greater than the equivalent of heat so won. An inner labor is thus produced, which in some unknown manner escapes as the evolved heat.

Z. H. Skraup, "*On Super-ferricyanide of Potassium.*" This body, already described by Städeler and Bong, but not analyzed, on account of its unstable properties, was obtained by the action of HCl and $KClO_3$ on red prussiate of potassium. It is black, amorphous, easily soluble in water, insoluble in alcohol, and possesses the composition K_3FeCy_3. Fe must be regarded as tetravalent in this case.

R. Maly, "*A New Derivative of Sulpho-carbamid.*" This consists of sulpho-carbamid-acetic acid—

$$CS.(NH_2)(NH.CH_2.COOH),$$

which can be regarded as a sulpho-hydantoic acid.

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P. LATSCHINOFF, "*Oxidation of Cholesterin.*" By the action of $KMnO_4$ on this substance the author obtains two monobasic acids, cholestenic acid, $C_{25}H_{42}O_4$, and oxycholestenic acid, $C_{25}H_{42}O_5$, and the dibasic dioxycholestenic acid, $C_{25}H_{42}O_6$. They are all soluble in ammonia, and yield amorphous salts with all metals except the alkalies. The author is led to adopt for cholesterin the formula $C_{25}H_{42}O$ $[(C_8H_8)_3H_2O]$.

F. Beilstein and A. Kurbatoff, "*Substitution Derivatives of Benzine.*" These chloro- and nitro-derivatives have been already described (*Chemical News*, vol. xxxv., page 105.)

G. Krestownikoff, "*On Iso-succinic Acid.*" In opposition to the statement of Byk, it is found that this acid is not produced by the action of potassium cyanide on chloro-propionic ether in alcohol. The reaction yields instead lactic acid and a new polymer of acrylic acid. The silver salt of iso-succinic acid is precipitated from the concentrated solution of the ammonium salt as a heavy granular mass. On the addition of water it is suddenly dissolved, and then immediately re-precipitated in the form of needle-like crystals. An attempt to obtain methyl-ethyl-acetic acid by the decomposition of ethyl-iso-succinate at a high temperature failed the ether remaining unchanged at the boiling-point of mercury.

H. Kanetnikoff, "*Action of Oxalate of Silver on the Bromides of the Olefines.*" The bromides of ethylen and propylen act in a similar manner to their homologues, the reaction producing instead of oxalic ethers, silver, bromine, carbonic acid, and ethylen or propylen.

C. Cech and P. Schwebel, "*New Formation of Iso-cyan-phenyl.*" The action of a dilute solution of a caustic soda on dichloro acetate of aniline yields hydrochloric acid, formic acid, and iso-cyan-phenyl.

THE ALKALINE AND BORACIC LAKES OF CALIFORNIA.

By J. ARTHUR PHILLIPS, F.G.S.

IMMEDIATELY east of the range of the Sierra Nevada is an extensive region of alkaline lakes and hot springs, of which very large areas are almost totally barren, the only vegetation consisting of wild sage, yucca, a few cacti, and scanty tufts of bunch-grass.

This district affords, in its many extensive craters and in its lavas, basalts, and obsidians, the most conclusive evidence of its volcanic origin, while its solfataras and boiling springs may be regarded as the last representatives of active volcanicity.

Although this region is one of great scientific interest, and may eventually become industrially important, it appears to be but little known in this country, and it has therefore been thought that a brief description of the district, as well as that of the borax lakes, lying on the western side of the Sierra, might not be without interest to English readers.

The most remarkable of the alkaline lakes of this portion of California are Mono and Owen's Lakes. The former lies in a depression occupying a portion of an elevated plateau of desert land, situated at the eastern base of the Sierra Nevada, between the head waters of Owen's and Walker's Rivers. The distance from the summit of the range to the lake shore is about six miles, and the difference of elevation is about 6,000 feet. On all sides, excepting towards the Sierra, this lake is surrounded by a wide belt of desert, the total area of which is from 400 to 500 square miles.

Mono Lake is about fourteen miles long from east to west, and nine wide from north to south; but it was formerly much larger than it is at present; this is indicated by numerous terraces, by means of which the lines of its ancient shores may be readily traced.

The water of this lake, which has a high specific gravity, and is alkaline and extensively saline, is not easily thrown into waves, but is generally smooth and glassy. Near its north shore there are springs which have produced extensive deposits of tufa, some of which rise several feet above the surface in forms resembling gigantic fungi.

There are numerous islands in this lake, two of which are of considerable size, the largest being two and a half miles long from north to south, and the other about half a mile in length from east to west. These, as well as a group of smaller islets lying to the north, are entirely composed of volcanic materials.

On the northeastern corner of the larger island are extensive hot springs and steam-jets, covering an area of some thirty acres, and extending into the lake. The escape of steam and hot gases from so many hundreds of vents is attended with much noise, and the sides of the orifices of many of the fumaroles are incrusted with a reddish-brown substance, which is probably chloride of iron. In the neighborhood of these springs there is a slight smell of sulphurous acid, but no free sulphur is deposited. Some of them furnish a copious supply of boiling water, large quantities of which enter the lake, and so perceptibly raise its temperature for a considerable distance around. Much gas and steam escape from a fissure caused by the sinking of a portion of the crust, while on the eastern part of the island are two well-defined craters, now filled with water.

Mono Lake is, during the summer, the resort of myriads of gulls and other aquatic birds, which are most numerous during the breeding season, but the water is believed to be entirely destitute of life, with the exception of a small crustacean, *Artemia fertilis*, nearly related to the so-called brine shrimp (*Artemia Salina*) found in the strong brine of the salt pans on European coasts, and the *Koo-cha-bee* of the Indians, a whitish larva, occurring in immense quantities, and which is much esteemed by them as an article of food.

Stretching south of the lake is a chain of extinct volcanoes, presenting the form of truncated cones, of which the generally steep sides are covered with ashes and other loose materials. Obsidian and pumice are abundant on the surface of these cones, and also cover the plains at their base.

Owen's Valley is a narrow basin lying south of Mono Lake, and running nearly north and south for a distance of about 140 miles. Its average width may be taken at ten miles. It is bounded along its western edge by the Sierra Nevada, which in this portion of its course presents an almost unbroken wall, of which the highest peak, opposite Owen's Lake, reaches an elevation of 15,000 feet. No pass crosses it at a less height than 11,000 feet, and near the lake shore the descent from the summit to the valley beneath must have an average inclination of at least 1,000 feet per mile, the distance being from ten to eleven miles, and the difference of level between the highest point of the pass and the valley being from 10,500 to 11,000 feet.

On the eastern side of this valley are the Inyo Mountains, towards its southern end, and the white Mountains further north. This range is dry and desert-like, and not a single stream of any size flows from it into Owen's Valley, which is exclusively watered by the melting of the snows accumulated during the winter months on the eastern slope of the Sierra. Owen's River rises a short distance from the source of the San Joaquin, and, after flowing for a distance of 120 miles, falls into Owen's Lake in lat. 36° 20′ N., long. 118° W. from Greenwich. This lake, of which the water is exceedingly saline and strongly alkaline, is twenty miles long and eight wide. It has no visible outlet, and its shores are often thickly coated with a snow-like alkaline incrustation.

No fish inhabits its waters, but *Koo-cha-bee* is abundant, and at certain seasons is carried in by the waves and deposited on the shores in layers of several inches in thickness. This was formerly collected in large quantities by the Indians, and, after being dried in the sun, rubbed between the hands and roughly winnowed, was crushed in a stone mortar, and made into a sort of bread, which furnished an important article of food. This insect, which has been described as a white grub, is also found abundantly in the waters of Great Salt Lake, Utah, and those of other saline and alkaline lakes of the West, and appears to be the larva of a two-winged fly which is described by the late Professor Torrey under the name of *Ephydra californica*, and by Dr. A. S. Packard as *Ephydra gracilis*.*

A specimen of water taken from Owen's Lake in January, 1866, had a specific gravity of 1·076, and contained 7128·24 grains of solid matter per gallon. The composition of this residue was found, calculated on an imperial gallon, to be as follows:

Chloride of sodium	2942·05
Sulphate of sodium	956·80
Carbonate of sodium	2914·43
Sulphate of potassium	122·94
Phosphate of potassium	35·74
Silicate of potassium	139·34
Organic matter	16·94
	7128·24

In addition to the substances above enumerated, iodine was present, but only in such minute proportion that its amount could not be estimated. It is also to be observed that since, for convenience of carriage, the sample of this water operated on was reduced by evaporation to one fourth of its original bulk before being brought to this country for analysis, it is probable that some alkaline sesquicarbonates may have been originally present.

The incrustations, which at certain periods of the year accumulate to the extent of many hundreds of tons on the shores of this lake, mainly consist of carbonates of sodium, in which the proportion of sesquicarbonate is somewhat variable; in some specimens examined monocarbonates were alone present. Besides carbonates of sodium, these deposits contain 3 per cent. of chloride of sodium, and about 5 per cent. of sulphate of sodium, together with traces of silica.

It was proposed some years since to erect works on the eastern shore of Owen's Lake, for the purpose of refining this deposit, for the manufacture of merchantable carbonate of sodium; but whether this idea was ever carried out, I am not aware. The only serious obstacles to the success of such an enterprise would appear to arise from scarcity of fuel, and the great distance of the lake from a shipping port.

As this lake continuously receives the waters of a considerable and constantly flowing river, while it has no apparent outlet, it follows that it must act the part of a hugh evaporating basin, in which the salts introduced by the not apparently saline water of Owen's River become concentrated to an alkaline brine. The rocks on either side of the valley through which the river flows are, to a very large extent, composed of granites, lavas, and basalts, from decomposition of the felspars in which the alkaline salts of the lake have doubtless been derived. The very small proportion of potassium salts present in these waters is remarkable, for although from the circumstance of the felspars of the district being to a large extent triclinic, sodium might be expected largely to predominate, still so great a disproportion in the respective amounts of the two alkalies could scarcely have been anticipated. This circumstance may perhaps, to some extent, be accounted for by supposing the potassium salts to have been largely assimilated by plants during the percolation of the waters containing them through vegetable soil, while the salts of sodium, not having been thus arrested, have passed into the river, and thence into the lake.

Owen's, like Mono Lake, was at one time much more extensive than it is at present; this is evident from the occurrence of a series of parallel terraces, plainly traceable on each side of the valley. In addition to these lakes, numerous alkaline lagunes and boiling springs are met with throughout this region.

The *Artemia fertilis*, before referred to as being plentiful in Mono Lake, is also exceedingly abundant in Owen's Lake. A peculiarity of this crustacean is that it congregates into masses which have often a strange appearance in the water. These masses sometimes stretch out in such a way as to have the form of a serpent, while at others they represent circles or various irregular figures. A gentle breeze scarcely affects water filled by *Artemia*, so that while on all sides the water is slightly ruffled, that which is occupied by these dense aggregations remains perfectly smooth, thus indicating the figure of the mass. On placing some of these crustaceans in a bottle filled with lake water, for the purpose of preserving them for subsequent microscopical examination, it was found that those which died rapidly disappeared, and on closely examining what had taken place, it soon became evident that, as soon as vitality had ceased, chemical action was set up, and the animal gradually dissolved in the strongly alkaline brine.

Burton Springs are situated at the extreme northern point of Owen's Valley. These springs rise from the earth over an area of about eighty square feet, which forms a basin or pond that pours its heated waters into a narrow creek. In this basin a vegetable growth is developed at a temperature of about 160° F., and is continued into the creek to a distance of about a hundred yards from the springs; where, at a temperature of about 120° F., the algæ grow to a length of over two feet, looking like bunches of waving hair of a beautiful green color. Below the temperature of 100° F., these plants cease to grow, and give way to a slimy fungus, which is also green in color, but finally disappears as the temperature of the water decreases. Dr. J. H. Wood, Jr., who has carefully examined this growth, makes the following observations with regard to it: "This plant certainly belongs to the *Nostochaceæ*, and seems a sort of connecting link between the genera *Hormosiphon* of Kützing and *Nostoc*.

"The best algologists now refuse to recognize the former group as generically distinct, and the characters presented by this plant seem to corroborate this view.

"The species appear to be an undescribed one, and I would propose for it the specific name *Caladarium*, which is suggested by its place of growth."†

Twenty miles south from Owen's Lake, across a sage-brush and grease-wood waste, the surface of which is plentifully strewn with fragments of lava, pumice, and basalt, is Little Lake. This sheet of water, which is of comparatively small extent, is surrounded by hugh masses of contorted vesicular lava, and evidently occupies the cavity of an ancient volcanic vent. The waters of this lake are considerably less alkaline than those of Owen's Lake, but bubbles of carbonic acid make their way to its surface in almost uninterrupted streams.

Fifteen miles east from this point are numerous hot springs; the path for the greater portion of this distance lies over lava-flows, which render traveling slow and fatiguing. At the principal group of springs the ground is covered, over a large extent, by innumerable cones of plastic mud, varying in height from a few inches to several feet; these rise above the surface of a seething swamp, and give issue to steam and jets of boiling water. In some cases the steam and gases, instead of issuing from cones as above described, are evolved under the surface water and mud contained in basin-shaped reservoirs formed in the decomposed rock. By these means are produced multitudes of boiling cauldrons in which violent ebullition keeps clay in a constant state of suspension; this clay varies in color from bluish gray to bright red. The waters of these springs are much employed by the Indians as an embrocation for the cure of diseases of the eye; on examination they were found to contain 48 grains of solid matter to the gallon, of which amount 26 grains are sulphate of aluminium; in addition they contain lime, soda, potash, and a little free sulphuric acid.

Borates of sodium and calcium occur in various localities in North America. The two borax lakes are both situated near the shores of Clear Lake in Lake County, California, seventy miles northwest of the port of Suscol, and one hundred and ten from the city of San Francisco.

The larger of these lakes is separated from Clear Lake by a low ridge of volcanic materials loosely packed together, and consisting of scoriæ, obsidian, and pumice; it has an average area of about three hundred acres. Its extent however varies considerably at different periods of the year, as its waters cover a larger area in spring than during the autumnal months. No stream flows into its basin, which derives its supply of water partly from drainage from the surrounding hills, and partly from subterranean springs discharging themselves into the bottom of the lake. In ordinary seasons its depth thus varies from five feet in the month of April to two feet at the end of October.

The borax occurs in the form of crystals of various dimensions imbedded in the mud of the bottom, which is found to be most productive to a depth of about three and a half feet, although a bore-hole which was sunk near its center to the depth of sixty feet afforded a certain amount of the salt throughout its whole extent.

The crystals thus occurring are most abundant near the center of the lake, and extend over an area equivalent to one third of its surface; they are, however, also met with in smaller quantities in the muddy deposit of other portions of the basin. The largest crystals, some of which are considerably above a pound in weight, are generally inclosed in a stiff blue clay, at a depth of between three and four feet; and a short distance above them is a nearly pure stratum, from two to three inches in thickness, of smaller ones; in addition to which crystals of various sizes are disseminated through the blue clayey deposit of which the bottom consists.

Besides the borax thus existing in a crystallized form, the mud itself is highly charged with that salt, and, according to an analysis by Dr. Oxland, affords, when dried, in those portions of the lake which have been worked (including the inclosed crystals), 17·73 per cent. Another analysis of an average sample, by Mr. G. E. Moore, of San Francisco, yielded 18·86 per cent. of crystallized borax. In addition to this, the deposit at the bottom of the other portions of the

* See Hayden, "Geological Survey of Montana, Idaho, Wyoming, and Utah, 1872," p. 744.

† "Silliman's Journal," vol. xlvi., 1868, p. 33.

basin, although less productive, still contains a large amount of borax.

Water collected from Borax Lake in September, 1863, was found by Mr. Moore to contain 2401·56 grains of solid matter to the gallon, of which about one half was common salt, one quarter carbonate of sodium, and the remainder chiefly anhydrous borax, equal to 535·08 grains of crystallized salt to the gallon. Traces of iodine and bromine were also detected. A sample of water taken from the interior of a coffer-dam sunk in the middle of the lake, and which had been allowed to fill by percolation from the bottom upwards, was found to be more concentrated, yielding 3573·46 grains of solid matter to the gallon, but it contained the same ingredients, and in nearly the same proportions, as the water from the lake itself. When evaporated to dryness, this water yields a considerable quantity of finely divided carbon, resulting from the various organic bodies which have been dissolved in it.

Mud from the bottom of Borax Lake is in high repute among the local Indians as an *insecticide*, and is used in the following way: The head of the patient is thickly plastered with mud, which is well rubbed in, and then allowed to become perfectly dry; when dry, it is removed by rubbing between the hands, and with it disappears the colony of parasites. Ordinary clay is, under pressure of circumstances, sometimes employed for this process of shampooing, but when alkaline or boracic mud is available, it is considered more efficacious.

When this locality was visited by me in 1866, borax was manufactured exclusively from the native crystals of crude salt, while the mud in which they were found was returned to the lake after a mechanical separation of the crystals by washing. The extraction of boracic mud was effected by the aid of sheet-iron coffer-dams. The only apparatus employed consisted of a raft, covered by a shingle roof, provided with an aperture in its center about fifteen feet square, above which were hung, by suitable tackle, four coffer-dams, each six feet square in horizontal section, and nine feet in depth. This raft, or barge, was successively moored in parallel lines across the surface of the lake, and at each station the four dams were sunk simultaneously by their own weight into the mud forming the bottom.

When they had thus become well imbedded, the water was baled out, and the mud and crystals removed, by means of buckets, into rectangular washing-vats, into which a continuous stream of water was introduced from the lake by Chinese pumps, the contents being at the same time constantly agitated by the aid of wooden rakes. In this way the muddy water continually flowed off, finally leaving a certain amount of crude borax at the bottom of each tank; this was purified by re-crystallization. From the density acquired by the 70,000 gallons of water daily employed for this purpose, it is evident that only about one half of the borax existing in the form of crystals was thus obtained, while the mud was again returned to the lake.

Instead of the coffer-dams, a small hand-dredging machine, worked, like the former, by Chinese labor, was subsequently introduced; but the mud brought up by it was subjected to the wasteful process of washing before described.

The crystals of crude borax thus daily obtained amounted to about 3,000 lbs.; these were dissolved in boiling water, and re-crystallized in large lead-lined vessels, from which the purified salt was removed to be packed into boxes, each containing 114 lbs., in which it was forwarded to San Francisco. The loss of weight experienced in the process of purification amounted to about 13 per cent.

Shortly after my visit in 1866, the manufacture of refined borax at "Big Borax Lake" was suspended, and I am not aware whether it has now been resumed, but the works do not appear to have been in operation in 1874.

Little Borax Lake covers an area of about thirty acres, and is usually dry during the months of September and October; it is then covered by a white crust, which is collected by Chinese laborers, and carried to the works, where it is refined by re-crystallization. *Ulexite*, a double borate of sodium and calcium, is brought to this place from Wadsworth, in the state of Nevada—a great distance, with several transhipments—to be treated at these works; it appears that on account of the presence of carbonate of sodium, and the cheapness of fuel, this can be done more cheaply here than in Nevada.

Clear Lake is a large and picturesque sheet of water, twenty-five miles long, by about seven wide, surrounded by mountains, which in many places rise abruptly from the water's edge. Boat life on this lake is delightful; the water is smooth, there is usually a sufficient breeze for sailing, and should it fall calm, an Indian can always be hired to row.

Lying about a mile beyond the ridge which borders Borax Lake on the northeast, and at the foot of a shorter arm of Clear Lake, which extends off to the southward parallel with the larger one, is an interesting locality, known as the "Sulphur Bank." It is some six or seven acres in extent, and consists of a much decomposed volcanic rock traversed by innumerable fissures, which has become almost covered by a large accumulation of sulphur.

From the fissures steam and gas are constantly issuing, and over and through the mass large quantities of sulphur have been deposited in such a way that at a short distance the whole bank appears to consist of this substance. Into some of these cavities a pole may be inserted for a distance of several feet, and they are often lined with stalactites and beautiful crystallizations of sulphur.

Sulphur is being constantly deposited, and its deposition is attended by the evolution of carbonic and boric acids. The gaseous matters issuing from these crevices appear to be the agency by which the various substances now deposited in the cavities have been brought to the surface. Sulphur is deposited on the sides of the various fissures either in the form of crystals or as amorphous translucent masses of a beautiful yellow color. It is sometimes intermixed with cinnabar, the presence of which was first discovered by Dr. Oxland; but more frequently with minute cubical crystals of iron pyrites. Pulverulent silica, blackened by some hydrocarbon resembling coal-tar, is also frequently observed.

On the sides of the cavities colloid silica is found coating chalcedony and opalescent quartz in the various stages of formation, from the gelatinous state to that of the hardest opal. The indurated material is sometimes colorless, but is more frequently permeated by cinnabar and iron pyrites, or blackened by the tarry matter before referred to. Cinnabar is also found in laminæ, and occasionally even in veins and concretionary masses of considerable thickness.

In addition to being employed as a source of sulphur, this deposit has been worked for quicksilver, and has produced large quantities of that valuable metal.

On the shore of Clear Lake, near the sulphur bank, is a hot spring, of which the outlets, even when the water is low, are partially beneath the lake, so that the amount flowing from it cannot be ascertained. Hot water, however, rises through the sand at various points extending over a considerable area. A specimen of water collected by Mr. Moore from this spring was found by him to contain 184·62 grains of common salt, 76·96 grains of bicarbonate of sodium, 36·37 grains of free carbonic anhydride, 103·29 grains of borax, and 107·76 grains of bicarbonate of ammonium, in an imperial gallon; besides silica, alumina, and traces of various other substances.

Professor Whitney remarks with regard to this spring: "The most extraordinary feature in the above analysis is the very large amount of ammoniacal salts shown to be present in this water, in this respect exceeding any natural spring water which has ever been analyzed. Mr. Moore thinks that, as in the case of the boracic acid waters of Tuscany, this ammoniacal salt may be separated and made available for economical purposes. This locality is worthy of a most careful examination, to ascertain how considerable a flow of water can be depended on."*

Dr. A. Blatchly, of San Francisco, in speaking of the Geyser group of quicksilver mines, says: "Nearly all these veins contain iron in considerable amounts, frequently in sufficient quantities to constitute an ore of iron. Gold, silver, and copper are also frequently constituents of these lodes, and occasionally chrome iron in considerable quantities. But, so far as is known, in no instance have the precious metals been sufficiently abundant to pay for the expense of extraction.

"Bitumen is found in nearly all these veins, sometimes a deposit of a gallon or two in one cavity.

"Thermal springs are numerous throughout the whole quicksilver region, and the uniformity of their occurrence leads prospecters to the belief that there is an intimate relation between the causes which generate thermal springs and produce deposits of cinnabar, and that where one is found the other may probably occur in the vicinity."†

On the eastern slope of the Sierra Nevada, near Walker's Pass; borax is found in what appears to be the bed of an ancient lake, large crystals of this substance having been met with in a hardened mud, exactly resembling those found in the blue clay of Borax Lake. By far the largest amount of borax is, however, obtained from the indurated mud, where it exists in common with other salts. This mud, from which borax is separated by lixiviation, contains about half its weight of that salt, and is a light clay-like body, having a strongly saline and alkaline taste. The portion insoluble in water effervesces on being attacked by hydrochloric acid, and contains silica, alumina, lime, ferrous oxide, and magnesia. Similar deposits containing borax exist in Panamit and Death's Valley, in Lower Nevada; but these desolate districts have not as yet received so careful an examination as they deserve.

About twenty miles west of San Bernardino is the so-called "Cane Spring District," where ulexite or boronatrocalcite is found, over an area about ten miles in width by fifteen in length. The surface of the ground is covered by efflorescent salts, commonly known as "alkali," beneath which the borax salts (chiefly ulexite) are found at a depth of only a few inches.

At Hot Springs, in the northwestern portion of the State of Nevada, at a height of 4,500 ft. above the level of the sea, and where the water issuing from the ground has a temperature of about 190° Fah., there are deposits of boronatrocalcite, extending over considerable areas. Here, as far as the eye can reach, nothing is seen but barren mountains, formed of a black porous lava: while the valleys are covered by an efflorescence of a mixture of common salt and sulphate and carbonate of sodium. In other cases the sands of these mountain valleys contain deposits of more or less pure boronatrocalcite.

Geysers and hot springs are numerous in the whole of this district, and from the number of extinct geyser vents still visible, they were, probably, at one time much more numerous than at present.

The analysis of an average sample of the boracic material from Nevada afforded Mr. Loew the following results:

Boronatrocalcite	22·13
Chloride of sodium	2·80
Sulphate of sodium	2·62
Sulphate of calcium	6·17
Carbonate of calcium	3·01
Carbonate of magnesium	0·79
Clay	19·70
Quartzose sand	26·03
Water	15·04
Traces of potash, iodine, and loss	1·71
	100·00‡

The purification of crude borax (*tincal*) is effected by a simple re-crystallization, but the preparation of marketable borax from boronatrocalcite is attended with considerable difficulty, more particularly as the appliances available in the remote deserts in which it occurs are of the most primitive and limited description.

When boronatrocalcite is moderately pure, it is first ground and subsequently dissolved in water, with the addition of an amount of carbonate of sodium sufficient to effect the decomposition of the calcic carbonate present.

The solution is subsequently heated, and the carbonate of calcium allowed to subside, when the liquor is drawn off, and, after concentration, borax is obtained by crystallization.

Unfortunately, this mineral often contains notable quantities of gypsum, which transforms an equivalent amount of carbonate of sodium into Glauber salt, a relatively valueless product. This salt is also frequently present in the material operated upon, and thus materially adds to the difficulty of treatment. In order to avoid these difficulties, it has been proposed to treat native boronatrocalcite with sufficient sulphuric acid to transform the whole of the carbonate of calcium into gypsum, and to liberate boric acid, to be subsequently saturated by carbonate of sodium. Boronatrocalcite has also been treated with excess of hydrochloric acid in order to obtain crystallized boric acid, but neither of these processes has hitherto afforded very satisfactory commercial results.

The comparatively recent discovery of large quantities of this substance in Nevada will, no doubt, eventually, to some extent, affect the Tuscan producers of boric acid; but the fact that crude boronatrocalcite varies considerably in its composition, and that it is found in situations in which its local treatment would be almost impossible, has hitherto prevented this mineral from being extensively employed as a source of commercial borax.—*Popular Science Review.*

DESIGN FOR A COFFEE-POT IN OXYDIZED SILVER. BY H. VILLAIN, PARIS.—(*From the Workshop.*)

THE coloring for butter and cheese, which is very extensively employed in Denmark, is made by intimately mixing one part of annotto with half its weight of alcohol, digesting for a week, and then boiling with three to five parts of oil, until the annotto forms dark brown granules and ceases to impart color to the oil. The price depends in part on the kind of oil employed—rapeseed, olive, and other oils being used. To the cheese coloring a little turmeric is usually added. This coloring was first made by N. Blumensaadt, of Odense, but is now largely manufactured at Copenhagen. —*Phar. Zeitung*, No. 5.

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* "Geological Survey of California," p. 100.

† "Mineral Resources West of the Rocky Mountains," 1875, p. 176. Raymond.

‡ "Moniteur Scientifique," 1876, p. 1220.